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Tunnel Component of the Tunnel & Reservoir Plan (TARP) Proposed by the Metropolitan Sanitary District of Greater Chicago. Mainstream Tunnel System, 59th St to Addison St

Environmental Protection Agency, Chicago, Illinois. Region V

Prepared for

Booz-Allen and Hamilton, Inc., Bethesda, Maryland

Mar 76

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PB 263 311

DRAFT ENVIRONMENTAL
IMPACT STATEMENT

For the

TUNNEL COMPONENT OF THE TUNNEL
AND RESERVOIR PLAN (TARP)
PROPOSED BY THE METROPOLITAN
SANITARY DISTRICT OF GREATER
CHICAGO

MAINSTREAM TUNNEL SYSTEM,
59th STREET TO ADDISON STREET

Prepared by
United States Environmental Protection Agency
Region V
Chicago, Illinois 60604

March 1976

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ENVIRONMENTAL IMPACT STATEMENT

TUNNEL COMPONENT OF THE
TUNNEL AND RESERVOIR PLAN
PROPOSED BY THE
METROPOLITAN SANITARY DISTRICT
OF GREATER CHICAGO

MAINSTREAM TUNNEL SYSTEM
59th STREET TO ADDISON

Prepared by

United States Environmental Protection Agency
Region V
Chicago, Illinois

and

Booz, Allen and Hamilton Inc.
Bethesda, Maryland

APPROVED BY:

Francis T. Mayo

Francis T. Mayo
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5. Federal, State, and Local Agencies and Individuals Notified of this Action

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Senator Charles H. Percy
Representative George M. O'Brien
Representative Philip M. Crane
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EXECUTIVE SUMMARY

FOREWORD

This executive summary supplements the Draft Environmental Impact Statement (EIS) on the Tunnel Component of TARP, specifically the Mainstream Tunnel System from 59th Street to Addison Street. Copies of the Draft EIS may be obtained by writing the U.S. Environmental Protection Agency, Region V, Planning Branch, EIS Preparation Section, 230 South Dearborn Street, Chicago, Illinois 60604; or by telephoning the TARP project officer at (312) 353-7730.

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I. BACKGROUND INFORMATION

This chapter first defines the legal basis and the scope of the EIS and then describes the authority and program of the applicant for EPA funding, the MSDGC. Finally, the history and objectives of the Tunnel and Reservoir Plan (TARP) are reviewed. This chapter of the executive summary corresponds to Chapter I of the environmental impact statement (EIS).

1.1 LEGAL BASIS FOR THE EIS

The U.S. Environmental Protection Agency (EPA) is the administering agency for a major Federal environmental program entitled "Grants for Construction of Treatment Works."[1] This program allows the EPA administrator to provide financial aid to any state, municipality, intermunicipal agency, or interstate agency for the construction of publicly owned water pollution control facilities. The program will encourage reduction of point sources of water pollution and improve national water quality.

The EPA's granting of funds for a water pollution control facility may require an EIS. Each proposed water pollution control facility is evaluated on a case-by-case basis by the appropriate EPA regional office to determine whether the proposed facility is expected to have significant environmental effects or be highly controversial. The EPA has prepared this EIS because it expects the environmental effects of the tunnel system to be significant.

This EIS is being issued pursuant to P.L. 91-90, the National Environmental Policy Act (NEPA) of 1969, and Executive Order 11514, "Protection and Enhancement of Environmental Quality" dated March 5, 1970. Both NEPA and Executive Order 11514 require that all Federal agencies prepare such statements in connection with their proposals for major Federal actions significantly affecting the quality of the human environment.

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[1] Authorized by Title II, Section 201(g)(1), of the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (FWPCA.A).

This EIS has been prepared in accordance with the regulations and guidance set forth in the President's Council on Environmental Quality (CEQ) Guidelines dated August 1, 1973, and the EPA's Final Regulations 40 CFR-Parg 6, dated April 14, 1975.

1.2 SCOPE OF THE EIS

The EIS addresses the cumulative effects of constructing and operating three conveyance tunnel systems which are part of the total Tunnel and Reservoir Plan (TARP) proposed by MSDGC. These three tunnel systems are:

- Mainstream (59th Street to Addison Street)
- Calumet
- Lower Des Plaines.

Where appropriate, this statement also assesses the effects associated specifically with a segment of the Mainstream Tunnel system route from 59th Street to Addison Street. Two subsequent statements will address separately the effects associated with the Calumet Tunnel system and the Lower Des Plaines Tunnel system. These tunnel systems comprise what is referred to in the statement as "TARP, Phase 1."

The subject of these statements is confined to the tunnel systems and their associated components because EPA is now considering whether to grant funds to construct these tunnels under its water pollution control authority. Other components of TARP, including the reservoirs, flood relief tunnels, instream aeration, and wastewater treatment plant improvements, are either ineligible for EPA funding or are not now under consideration for construction grants. Therefore, these other components are not considered to be part of the proposed action under review. The effects of these other components on water quality and the likelihood of their being financed is analyzed in this EIS in order to provide a context for evaluating the significance of the water quality improvements expected from the three tunnel systems.

1.3 IDENTIFICATION OF THE APPLICANT

The Metropolitan Sanitary District of Greater Chicago (MSDGC) is the construction grant applicant for the component of Tunnel and Reservoir Plan (TARP) addressed by this EIS. The MSDGC was organized in 1889 under an act to create sanitary districts to remove obstructions in the Des Plaines and Illinois Rivers.[1] Under the provisions of the act, the MSDGC is responsible for providing surface water and sewage drainage within the District's boundaries, which it does by constructing necessary facilities, conveyance systems, and treatment plants. The MSDGC is authorized to treat wastewater, either totally or partially, from any municipality within its designated jurisdiction, as well as to own and operate all wastewater facilities located within the MSDGC jurisdiction.

The MSDGC service area is approximately 860 square miles. Approximately 44 percent of this area, or 375 square miles, is served by MSDGC-owned combined-sewer systems (see Figure I-1) in which wastewater or sewage collected in local sewer systems is conveyed to treatment plants. These systems serve 120 municipalities which have a total population of approximately 5.5 million. The District owns and operates 70.5 miles of navigable canals, 6 wastewater treatment plants, and approximately 440 miles of intercepting sewers. The three major plants (North-Side, West-Southwest, and Calumet) in the MSDGC service area have a secondary capacity of over 1,750 million gallons per day (MGD). The remaining plants have a combined tertiary capacity of over 70 MGD. A water reclamation plant, the John F. Egan plant, is presently under construction and will have a capacity of about 30 MGD.

1.4 PROJECT HISTORY

The MSDGC initiated its wastewater facilities planning study in September 1967, with a ten-year clean-up and flood control program. The objectives of the program are to solve the District's flooding problem, protect Lake Michigan from further pollution, and improve the water quality of rivers and streams in the Chicago metropolitan area. The Tunnel and Reservoir Plan (TARP) has evolved from this ten-year program.

Concerned officials from the State of Illinois, Cook County, the MSDGC, and the city of Chicago reactivated a Flood Control Coordinating Committee (FCCC) in November 1970 to investigate the pollution and flooding problems in the Chicago metropolitan area. The Committee's primary assignment was to develop a viable plan to minimize the area's

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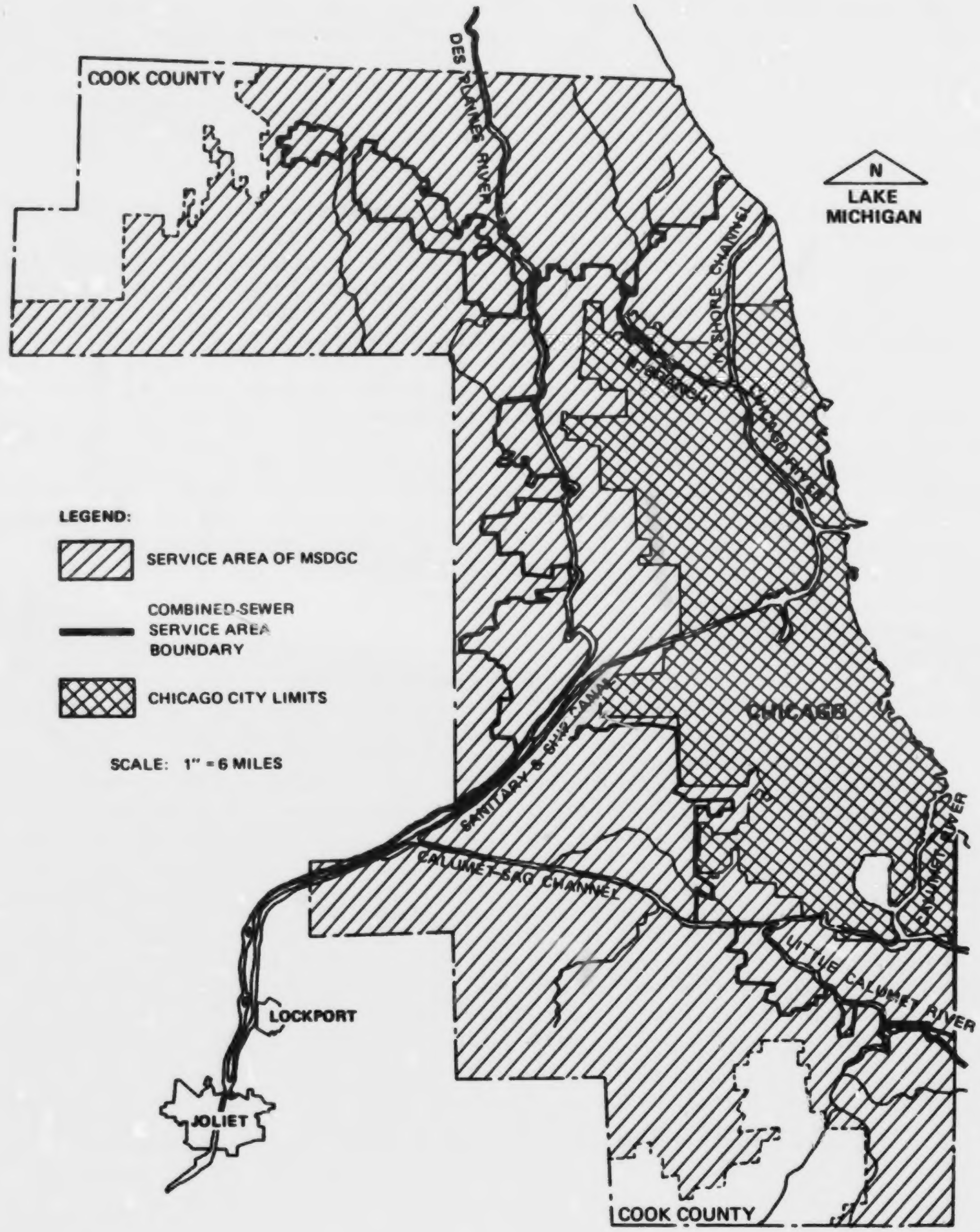
[1] Illinois Revised Statutes, Chapter 42, Section 320, approved May 29, 1889.

FIGURE I-1
Metropolitan Sanitary
District of Greater Chicago
Service Area


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
NORTH SHORE CHANNEL
N. BRANCH
CHICAGO RIVER
LEGEND:
SERVICE AREA OF MSDGC
COMBINED-SEWER SERVICE AREA BOUNDARY
CHICAGO CITY LIMITS
SCALE: 1" = 6 MILES
CHICAGO
SANITARY & SHIP CANAL
CALUMET-SAG CHANNEL
CALUMET RIVER
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY

pollutant discharges and the flooding caused by overflows of mixed sewage and wastewater. Another priority item in the plan was elimination of the need to release polluted river and canal flood waters into Lake Michigan. The Committee's plan was to address the combined-sewer area within Cook County, covering 375 square miles. The deliberations and studies of the FCCC and of a technical advisory committee which they formed resulted in the selection of TARP as less costly and more environmentally acceptable than the other plans they evaluated. The Committee then initiated additional studies to develop and refine TARP.

1.5 OBJECTIVES OF TARP

A primary objective of TARP is to improve surface water quality within the planning area. TARP is designed to meet the standards set forth in the "Water Pollution Regulations of Illinois."[1] These regulatory standards were established for three surface water-use classifications: (1) General (primary body contact), (2) Public and Food Processing (drinking water), and (3) Secondary Body Contact and Indigenous Aquatic Life. All surface waters in the State of Illinois have been given a water-use classification by the Illinois Pollution Control Board (IPCB) and should comply with the appropriate water quality standards. Details of these standards are presented in Chapter II of this EIS. Other important objectives of TARP are to:

- Preserve the health and well-being of the population
- Prevent further pollution of Lake Michigan due to backflow
- Utilize treated waste byproducts
- Prevent flooding.

The final TARP is a combination of several alternative plans designed to collect urban runoff during all wet weather conditions except those storms of a magnitude equal to the three most severe storms recorded to date by the U.S. Weather Bureau Service.

II. EXISTING ENVIRONMENTAL SETTING

To provide a basis for assessing the impacts of a proposed project, an EIS initially describes the existing natural, social, economic, and cultural setting of the area which may be affected by a project. This chapter summarizes the major findings of the EIS with respect to the natural and man-made environments of the Chicago metropolitan area. This chapter is divided into two sections which correspond to Chapters II and III of the EIS text: Natural Environment and Man-made Environment.

2.1 NATURAL ENVIRONMENT

The existing natural environment of the Chicago area summarized in this section focuses on those features relevant to impact assessment of the proposed TARP project. This section is divided into the following categories:

- Water Resources
- Land Resources
- Atmospheric Resources.

2.1.1 Water Resources

The surface water systems of the Chicago area consist of a network of rivers and canals whose natural flow into Lake Michigan is controlled by a series of locks and one lakes. These surface water systems include the Chicago River, the Sanitary and Ship Canal, the Calumet River system, and the Des Plaines River system. Lake Calumet and Lake Michigan also constitute an important part of the area's surface water resources.

The quality of the surface water systems is affected by steady-state effluent discharges and by injections or discharges of polluted wastewaters. The polluted wastewater results from overflows of combined-sewer systems during rainfall events of nominal size (approximately 0.1 inches or greater). The frequency of these rainfall events is approximately 100 times per year, and the resulting overflows are discharged directly to the Chicago area's streams and rivers.

Pollutant concentrations in the streams and rivers presently exceed water quality standards established by the State of Illinois Pollution Control Board. Concentration ranges of various pollutants in the Chicago area's surface systems are presented in Table II-1. Further details on the water quality of specific water systems are presented in Section 2.1.1 of the EIS.

Table II-1
Summary of Pollutant Concentration Ranges in Chicago's Surface Water Systems

Pollutant	Chicago River — Sanitary and Ship Canal System	Calumet River System	Des Plaines River System	Applicable Illinois Standards*	
				Secondary Contact	General Use
Dissolved oxygen (DO)	1.2 to 7.7 mg/l	3.9 to 9.0 mg/l	6.0 to 10 mg/l	5.0 mg/l[1] 4.0 mg/l (1978)[2] 3.0 mg/l 4.0 mg/l min.[1] 2.0 mg/l min.	6.0 mg/l 5.0 mg/l min.[3]
Biochemical oxygen demand (BOD)	5.2 to 9.2 mg/l	4.1 to 7.3 mg/l	5.0 to 6.7 mg/l	4-20 mg/l[4]	4-20 mg/l[4]
Ammonia (as N)	0.8 to 6.2 mg/l	1.3 to 13 mg/l	0.3 to 1.2 mg/l	4.0 mg/l (winter) 2.5 mg/l (summer)	2.6 mg/l[3]
Suspended solids (SS)	19 to 54 mg/l	12 to 73 mg/l	29 to 68 mg/l	5-25 mg/l[5]	5-25 mg/l[5]
Fecal coliform	477 to 12,700 (counts/100 ml)	152 to 738 (counts/100 ml)	411 to 8,700 (counts/100 ml)	1000/100 ml[1]	200/100 ml[2]

* Effluent discharge standards apply if water quality standard is not designated.

1 North Shore Channel Standards

2 Chicago River-Sanitary and Ship Canal System and Calumet River system.

3 General Use Standard applicable to Des Plaines River system.

4 4 mg/l-Hanover, Egan, and O'Hare Sewage Treatment Plants
10 mg/l-WSW and Calumet Sewage Treatment Plant
20 mg/l-Lemont Sewage Treatment Plant

5 5mg/l-Hanover, Egan, and O'Hare STP
12mg/l-WSW and Calumet STP
25mg/l-Lemont STP

Serious public health problems involving contamination of Chicago's drinking water supply has led to implementation of regulatory measures to protect Lake Michigan, an important drinking water resource, from pollution. Locks and gates have been installed to divert river flows away from Lake Michigan, allowing eventual drainage into the Illinois River. Lake Michigan supplies most of the drinking water for the Chicago area. The withdrawal amount is approximately 1,600 cubic feet per second (CFS), and the maximum amount that can be withdrawn from Lake Michigan is 3,200 CFS.[1] This withdrawal limit, or allotment, is presently divided into three usage types: domestic water supply, indirect waterway diversion, and direct waterway diversion. The diversion usages allow improved effluent dilution and improved navigation.

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[1] Supreme Court Decision.

In the Chicago metropolitan area, there are two main aquifer systems: the upper aquifer, which consists of glacial drift and dolomites, and the lower aquifer, which consists of dolomite and sandstone formations. Unconsolidated Quaternary deposits and Silurian dolomites of the upper aquifer are hydraulically connected and function, in most areas, as a single water-bearing unit. Clayey deposits in the glacial drift act as confining layers to create artesian conditions in the upper aquifer. The lower aquifer includes dolomite and sandstone formations extending from the base of the Maquoketa Group to the top of the Eau Claire shales of the Cambrian system. The average thickness of the upper aquifer and lower aquifer is approximately 400 feet and 1,000 feet, respectively. The sources of recharge for the groundwater in the upper aquifer are infiltration of precipitation and influent streams. The lower aquifer is recharged in parts of McHenry, Kane, and De Kalb Counties where the Maquoketa Group outcrops, and further west where the Group has been removed by erosion. With respect to using the aquifers as a water resource, studies indicate that the lower aquifer is capable of producing about 25 Million Gallons per Day (MGD) and the upper aquifer is capable of a potential yield of 108 MGD.

Discharges into the waterways of the Chicago area originate from several sources, including: wastewater treatment facilities, industrial plants, and combined-sewer overflows. Six wastewater treatment facilities currently discharge treated water to existing waterways. The outfalls are located adjacent to the facilities. Most of these facilities are in compliance with the BOD and SS effluent standards (under present permit conditions), and two smaller plants are within the ammonia-nitrogen standard. With respect to industrial plants, wastewater is conveyed to treatment plants and processed before discharging. The industrial waste load averages approximately 195 MGD or equivalent to a population of 4.5 million. Combined-sewer overflows, which occur about 100 times per average year, inject pollutants in large amounts into waterways at approximately 640 outfall points in the Chicago area. During such events, minimum Illinois water quality standards established for restricted-use waters are not met.

Numerous water resource management programs have been initiated to address the flooding and/or pollution problems of the Chicago area. These programs have been or are currently being conducted either regionally or locally. A few of these programs include: the Section 208 Areawide Waste Treatment Management Planning program, the Chicago-South End of Lake Michigan study (C-SELM), the City of Chicago

Sewer Construction program, Thornton Quarry Flood Control project, and the Chicago Metropolitan Area River Basin Plan (CMARBP).

2.1.2 Land Resources

The Sanitary and Ship Canal and the Calumet-Sag Channel have significantly altered the natural drainage patterns which are from west to southwest in the area near Lake Michigan. Prior to construction of the Canal and Channel, the drainage flow was toward Lake Michigan. The flow is presently toward the Chicago River and the Sanitary and Ship Canal, which drain into the Illinois Waterway system. The overall low relief of the MSDGC combined-sewer system area makes it prone to flooding caused by sewer system backups and/or overbank flows. The areas with the highest overbank flooding potential lie along the North Branch-Chicago River and in the Calumet River system.

The Chicago area lies on the broad, gently sloping, northwesterly-trending Kankakee Arch. This arch, which connects the Wisconsin Arch to the northwest with the Cincinnati Arch to the southwest, separates the Michigan Basin from the Illinois Basin. The northeast sector of the Chicago area lies on the northeastern side of the Kankakee Arch, while the southwestern sector of the Chicago area lies on the southwest flank of the Arch. In the Chicago area, overall, a number of gentle east-west-trending folds are superimposed on the area's broad regional geologic structures. Numerous minor faults and several major faults have been mapped, including: the Sandwich fault near Joliet and the Des Plaines disturbance near the community of Des Plaines. The uppermost 500 feet of rock layers, particularly the dolomites and shales between the top of the Racine formation and the base of the Brainard formation, will be relevant to the proposed construction of the TARP tunnel systems. The surface layer (glacial deposits) has an average thickness of approximately 80 feet. Drop shaft and construction shaft installations will be constructed within this layer.

Based on 175-year historical earthquake records, four major earthquakes occurred within 100 miles of Chicago with intensities equal to or greater than MMI VIII (Modified Mercalli Intensity scale). These earthquakes originated at Fort Dearborn (Chicago) (1804), near Rockford (1909), near Aurora (1912), and near Amboy (1972). Within the MSDGC combined-sewer service area, there are 30 faults with moderate vertical displacement characteristics and 86 minor faults with small vertical displacement characteristics.

2.1.3 Atmospheric Resources

Air quality in the Chicago metropolitan area is presently monitored by the city of Chicago Department of Environmental Control and the Cook County Department of Environmental Control. A total of 61 monitoring stations have been established in Cook County; 30 of these are located within the city limits of Chicago. Based on the 1974 Annual Air Quality Report published by the State of Illinois EPA, ambient air quality standards were frequently violated at one or more stations. The pollutant standards violated include: sulfur dioxide, particulate matter, carbon monoxide, hydrocarbons, and photochemical oxidants (measured as ozone).

The existing outdoor noise levels in most areas of Chicago are caused mainly by street traffic. Other noise sources include trains, aircraft, and industrial plants in city areas, and power lawn mowers, power tools, and other motor-driven equipment in residential areas. Based on a recent EPA study, typical noise levels for the Chicago area ranged from 36.3 dBA (decibels-A scale) (night) to 106.2 dBA (day). The day-night level (L_{dn}) ranged from 59.0 dBA to 71.2 dBA (overall average).

2.2 MAN-MADE ENVIRONMENT

The various components related to man's activities in the Chicago area are summarized in this section. These components include: Socioeconomic, Land Use, Sensitive Areas, Financial and Labor Resources, Transportation, and Major Projects and Programs.

2.2.1 Socioeconomic

The Chicago metropolitan area has experienced growth and change in its demographic profile similar to other major cities in the United States. Chicago, the third largest standard metropolitan statistical area (SMSA) in the United States, has experienced typical population redistribution trends within the SMSA. The close-in suburban jurisdictions grew rapidly during the 1950's from a substantial in-migration of population from the south and an out-migration of people from the city of Chicago. During the 1960's, the counties adjacent to Cook County urbanized rapidly. Continued redevelopment of the City, when combined with smaller household trends, uncertainties regarding energy availability and cost, and the increasing cost of suburban new construction, should result in a strengthening of the urban centers and a lessening of the outward population movements. Chicago's population is expected to stabilize after 1980.

Contract construction income accounts for less than eight percent of total earnings in the Chicago region. While average monthly wages for construction employment are high relative to other industries in the Chicago region, total earnings from contract construction have ranged from 6.5 to 7.7 percent of total earnings over the period 1950 to 1971. The construction industry is heavily unionized, and the current union hourly wage rate averages $11.02. (Refer to Table III-6 of the EIS).

Chicago has traditionally sustained strong construction activity in the public and private sectors. Major public redevelopment projects have stimulated private investment and development, particularly within the city of Chicago. Construction employment opportunities have thus attracted and created a large construction labor force. Construction employment in the Chicago SMSA numbered 136,897 people in 1970 or approximately 4.8 percent of the total employed. Construction employment in the Chicago SMSA accounted for 61 percent of total construction employment in the State of Illinois. The Chicago area construction work force is highly flexible and can expand rapidly, given the demand for construction services.

2.2.2 Land Use

The predominant land use bordering the Mainstream Tunnel route can be characterized by its industrial zoning; large portions are underutilized and vacant. The notable exception to industrial land use is commercial development characteristic of the Central Business District (CBD) which borders the tunnel segment following the Chicago River from Lake Michigan to Wolf Point. There are no residential land uses bordering the tunnel route. Rock taken from the tunnel will probably will be disposed of at McCook, Stearns, and Thornton quarries. Sludge will be disposed of at a number of sites or by a number of programs, including: the Fulton County project, NuEarth, broker sales, Lawndale Lagoons, and other landfills.

The land areas bordering the proposed tunnel route are expected to change to park, cultural, and recreational uses in the CBD-related sections but remain generally the same along other segments. Implementation of the Chicago 21 Plan would realize the Riveredge Plan, affecting redevelopment bordering the Main Branch of the Chicago River from Lake Michigan to Wolf Point. Substantial new recreational park development along the riveredges are envisioned.

Plans also call for the strengthening of the North Branch Industrial Area. Industrial uses along the Sanitary and Ship Canal are likely to continue because of the need for low-cost water transport. Improved water quality in the river and the canal plus storm water management would enhance the proposed Riveredge Plan and would help strengthen the industrial areas.

2.2.3 Sensitive Areas

There are no known archeological or historically significant sites bordering the tunnel route. MSD is presently investigating areas adjacent to planned tunnel routes. There are selected sites of historic and architectural interest within the vicinity of the tunnel route, but none within the immediate 500-foot impact area of the tunnel. These sites are listed on pages III-16 and III-17 of the EIS.

2.2.4 Financial Resources

Financial resources are currently available to fund the Mainstream Tunnel system. TARP's Phase 1 tunnel system cost breakdown is approximately $1.03 billion[1] for water pollution elements and $0.81 billion for flood control measures. Operation and maintenance of TARP has been estimated at $13 million annually. The estimated cost of the Mainstream system alone is $508.2 million, with an annual maintenance cost of of $2.3 million.

Analysis of the funding resources required to finance the Mainstream Tunnel system reveals that sufficient funds are currently available from the Federal Government, the State, and the MSDGC. (See Section 3.3.1 of the EIS). Additionaly Federal Water Pollution Control funds of approximately $221.0 million and MSDGC funds of about $73.5 million will be required to meet the implementation plan for the other conveyance tunnel systems. In view of the sound fiscal posture of the MSDGC, the high funding priority assigned TARP by the State, and the very conservative estimates of future Federal appropriations, it can be reasonably assumed that future financing requirements can be satisfied.

Maintenance costs can either be covered through an ad valorem property tax, or through a user charge system based on water consumption. EPA favors the latter approach and has awarded the MSDGC two grants to develop such a user charge system.

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[1] Cost estimates based on values presented in MSDGC's "Facilities Planning Study—MSDGC Overview Report," January 1975.

2.2.5 Labor Resources

Labor resources are considered adequate to meet construction and implementation needs of TARP and other projects. The diversified labor force in the Chicago metropolitan area is vulnerable to economic recession because of the emphasis upon manufacturing and nonservice employment. Thus, while national unemployment was about 8.4 percent in the third quarter of 1975, Cook County had a 9.6 percent rate, and the city of Chicago sustained a 11.2 percent rate of unemployment. Increasing productivity rates and an expanding labor force should contribute to keeping Chicago unemployment levels higher than the national rate for the next few years. Therefore, new employment opportunities presented by TARP and other projects should not experience a shortage of labor resources.

The labor force is predominantly male, with white collar workers comprising 53 percent of the labor force in the SMSA.

2.2.6 Transportation

Implementation of the Mainstream Tunnel system will involve use of roadways and waterways. Trucks carrying rock and spoil material from construction sites will utilize several surface streets and expressways in reaching the quarry sites. The roadways range from two-lane streets to six-lane divided highways. The Mainstream Tunnel route also is proximate to major Chicago waterways; the North and South Branches of the Chicago River and the Sanitary and Ship Canal. Other portions of TARP will be near the Calumet and Little Calumet Rivers, and the Calumet-Sag Channel. Waterborne commerce is important to the Chicago economy; of the 46.2 million tons of waterborne freight traffic handled by the Port of Chicago, 37 percent or 17.1 million tons are moved over the inland waterways.

2.2.7 Major Projects and Programs

Major projects and programs proposed over the next ten years in the vicinity of the Mainstream Tunnel route consist mainly of transportation system improvements. Major transportation-related improvements which are proposed include:

- Monroe Street Subway Line
- Franklin Street Subway Line
- Crosstown Expressway
- Columbus Avenue - Monroe to Wacker, and northside of the Main Branch to Ontario Street
- Lake Shore Drive - relocation and construction from Monroe to Wacker
- Ashland Avenue - improvements from 83rd Street to Addison Street
- Rail and truck terminal improvements.

Other public projects include the proposed acquisition of rights-of-way along the north side of the Sanitary and Ship Canal. These rights-of-way are privately owned, and used by Commonwealth Edison and Natural Gas Pipeline Company of America for energy transmission. The intent of the public acquisition would be to establish a permanent utility corridor to more efficiently service growing energy demands.

An addition to Lane Technical High School is proposed, which is near drop shaft number 85, and two construction shafts just south of Addison Street on the east side of the North Branch. No other expansion plans are proposed in the vicinity of the tunnel project.

III. THE PROPOSED ACTION

Identifying and defining a plan and its systems and subsystems establishes the proposed action for which the environmental setting is described and the environmental impacts are assessed. The proposed action identified and defined for this EIS is the Phase I conveyance tunnel systems and their associated subsystems only. The planned storage reservoirs, waste treatment plant upgrading and expansion, on-line reservoirs, and instream aeration facilities were not included.

The information presented in Chapter IV and V of the EIS is summarized in this chapter and divided into seven parts:

- Alternative Plans
- Plan Selector
- TARP Tunnel Systems
- TARP Subsystems
- 59th-to-Addison Tunnel Segment
- Cost of Tunnel System and Subsystems
- TARP Financing.

3.1 ALTERNATIVE PLANS

Many plans to resolve the Chicago area's flooding and water pollution problems were developed during the past two decades by concerned government agencies, local organizations, and individuals. At first, the plans focused primarily on the flood control problem, however, as water quality conditions in the area worsened, more emphasis was placed on controlling the water pollution. A total of 23 plans were formulated, and many were evaluated in detail by a Flood Control Coordinating Committee (FCCC), consisting of representatives from the State of Illinois, Cook County, the MSDGC, and the city of Chicago.

In screening the alternative plans, the FCCC established overall flood and pollution control objectives which provided a basis for evaluating alternative plans. A plan was automatically rejected if it did not:

- Prevent all backflows to Lake Michigan to protect water supply resources

- Reduce pollutant discharges caused by combined-sewer overflows

- Reduce flooding in the combined-sewer and downstream areas.

In the initial screening, 6 plans were eliminated and the remaining 17 were modified to meet the objectives more fully as well as to provide a more quantitative basis for comparison. The modifications were referred to as MODs, and consisted basically of a combination of different storage capacities and waterway improvement actions. The resulting MODs yielded 51 alternative subsystem plans, or subplans, to be evaluated by the FCCC. In the next screening phase, the FCCC defined eight principal parameters, including capital costs (1972 dollars), estimated annual operating and maintenance costs (1972), project benefits, land acquisition acreage, underground easement requirements, resident and business relocations, construction impacts, and operation impacts. A technical advisory committee was organized by the FCCC to evaluate the modified alternatives in detail using the eight parameters. The advisory committee's interim report, "Evaluation Report of Alternative Systems," recommended a 50,000 acre-feet (ac-ft) storage level, which was part of the modified alternative designated as MOD 3. After reviewing the report, the members of the FCCC unanimously concluded that the flood and pollution control plan should be in the form of one of the four Chicago Underflow plans developed (four of the seventeen plans) or a combination of these plans, along with the recommended storage level. The FCCC stated that, "These alternatives are less costly and more environmentally acceptable to the community than any of the other plans presented. Detail studies along the lines of these alternatives should proceed to develop the final plan layout."

3.2 PLAN SELECTION

In August 1972, the FCCC members presented their final recommendations in a report with seven technical appendices. The report recommended consolidating the favorable features of the four Underflow plans into the Tunnel and Reservoir Plan (TARP). TARP was developed further and refined, then evaluated in detail with four selected alternatives and the "no-action" alternative. In this evaluation, 15 significant environmental impact parameters were identified as the basis for evaluation. The FCCC concluded that very few negative impacts are expected for any of the alternatives incorporating conveyance tunnels, and that adverse impacts will occur if the "no-action" alternative is chosen. The FCCC also concluded that the construction impacts of all plans on the environment will most likely be relatively short-term and localized. Finally, the beneficial impacts of the plans will far exceed the adverse impacts. Within the scope of the FCCC analysis, TARP had the highest ranking and was selected as the most suitable plan to solve the flood and pollution problems of the Chicago metropolitan area.

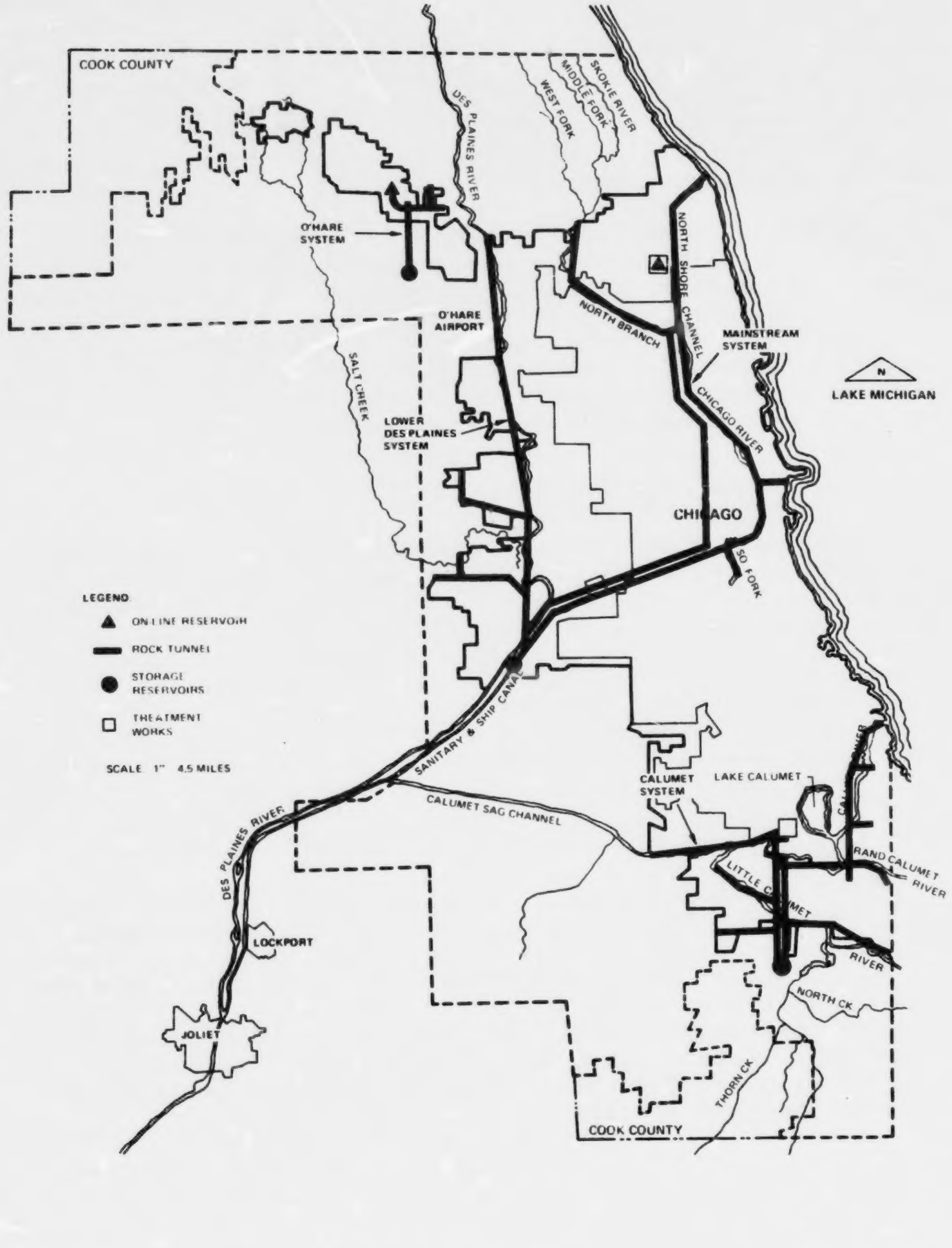
TARP would provide the most benefits for the lowest cost and the least adverse environmental impacts. Field studies and subsurface exploration programs further refined the plan; however, they did not change the original TARP concept. They were conducted only to optimize overall system effectiveness. Presently, TARP will enable collection of runoff water resulting from all but three of the severest rainfall storms recorded during the past 21 years.

3.3 TARP TUNNEL SYSTEMS

The four tunnel systems that are a part of the Tunnel and Reservoir Plan are the Mainstream, Calumet, Lower Des Plaines, and O'Hare systems. Each system is a completely independent operating unit with collection, storage, conveyance, and treatment capabilities. Figure III-1 shows the present routes and layout of these systems relative to the MSDGC combined-sewer service area, the MSDGC overall service area, and Cook County. Each of the TARP systems shown in the figure consists of three component systems: reservoirs, conveyance tunnels, and sewage treatment plants. A total of three reservoirs, 120 miles of conveyance tunnels, and four sewage treatment plants are included in the plan.

The TARP systems have two basic features which play a major role in solving the flood and pollution problems. First, the combined storage capacity of the plan is almost 136,800 ac-ft of which 127,600 ac-ft of the total is reservoir capacity and 9,200 ac-ft is tunnel capacity. The planned treatment capacity of TARP will be approximately 2,240 MGD. Second, over 640 existing overflow points will be eliminated within the MSDGC combined-sewer service area by the TARP systems.

FIGURE III-1
Tunnel and Reservoir Plan
System Layout and Routes


COOK COUNTY
DES PLAINES RIVER
WEST FORK
MIDDLE FORK
SKOKIE RIVER
O'HARE SYSTEM
O'HARE AIRPORT
NORTH BRANCH
NORTH SHORE CHANNEL
MAINSTREAM SYSTEM
N
LAKE MICHIGAN
SALT CREEK
LOWER DES PLAINES SYSTEM
CHICAGO RIVER
CHICAGO
SO FORK
LEGEND
ON-LINE RESERVOIR
ROCK TUNNEL
STORAGE RESERVOIRS
TREATMENT WORKS
SCALE 1" 4.5 MILES
SANITARY & SHIP CANAL
CALUMET SAG CHANNEL
CALUMET SYSTEM
LAKE CALUMET
GRAND CALUMET RIVER
LITTLE CALUMET RIVER
NORTH CK
THORN CK
DES PLAINES RIVER
LOCKPORT
JOLIET
COOK COUNTY

The proposed locations for the three reservoirs are: McCook quarry, Thornton quarry, and an area northwest of O'Hare International Airport. The conveyance tunnels, located 150 to 290 feet below ground level, will be constructed under existing waterways and public rights-of-way. Of the sewage treatment plants, three of the four plants are currently activated sludge plants with a combined planned capacity of approximately 2,150 MGD. The remaining plant is the proposed O'Hare-Des Plaines plant which will have a treatment capacity of over 70 MGD. A water reclamation plant, the John F. Egan plant, is presently under construction and the capacity will be 30 MGD.

3.4 TARP SUBSYSTEMS

The subsystems common to all TARP tunnel systems include drop shafts, collecting structures, and pumping stations. The drop shafts range from 4 to 17 feet in diameter and have two basic designs. One design features a slotted inner wall to assist in aerating the incoming water. The wall separates the air shaft from the water shaft and allows air either to enter or to escape while water is flowing in or being pumped out. The other design features a separate air shaft, to be installed in areas where high overflow rates prevail. The inside diameter of this drop shaft design ranges from 10 to 17 feet.

Approximately 640 collecting structures will be constructed to collect the overflows at established locations. The collecting structure basically consists of a diversion unit at the overflow point and a connecting pipe to the drop shaft entrance chamber. Most of the new structures will be constructed near curbs or in low points adjacent to major public thoroughfares.

Pumping stations will be constructed underground at the end of all conveyance tunnel routes and adjacent to all storage reservoirs. These stations permit a rate of dewatering of the tunnels and reservoirs which will allow a full tunnel or reservoir to be emptied within two to three days. The stations will also be used to transport bottom sludge dredged from reservoirs to treatment facilities.

3.5 59TH-TO-ADDISON TUNNEL SEGMENT

The Mainstream system of TARP consists of: two waste treatment plants with a total capacity of approximately 1,800 MGD; over 57 miles of conveyance tunnel with a storage volume of 3,180 ac-ft; and one main storage reservoir with a maximum capacity of 84,000 ac-ft. The component subsystems associated with the Mainstream system include 134 drop shafts; over 220 collecting structures; and one pumping station located at the main storage reservoir. The system and its component subsystems will be constructed in two phases. In Phase I, approximately 40 miles of tunnel will be constructed, and in Phase II, the remaining 17 miles will be constructed. The Phase II tunnel route is almost parallel to the 59th-to-Addison segment of the Phase I tunnel, as shown in Figure III-1, and it will be used as a relief tunnel.

Phase I construction has already commenced on the North Shore Channel segment from Addison Street to Wilmette Harbor. These segments, therefore, are not addressed in the Mainstream EIS. This EIS addresses the Phase I, 59th Street to Addison Street segment of the Mainstream system and focuses only on the conveyance tunnel system. The overall length of this tunnel segment is approximately 21 miles. The subsystems associated with it include 82 drop shafts, 5 construction shafts, 2 access shafts, 170 collecting structures, and 1 main pumping station.

3.6 COST OF TUNNEL SYSTEM AND SUBSYSTEMS

The MSDGC estimated cost[1] of a 10-foot diameter tunnel in rock with nominal aquifer protection is $200[2] per lineal foot. In rock with high quality aquifer protection, the cost is $230. Tunnel cost for soft ground construction is $350. Similarly, for a 35-foot diameter tunnel, the estimated costs are $1,030, $1,090, and $1,680 per lineal foot, respectively.

Large rectangular tunnels adjacent to construction shafts will be excavated by the drill and blast method and the estimated cost with nominal aquifer protection is $2,090 per lineal foot tunnel, and $2,580 for a 49-foot diameter tunnel. The same type and size of tunnels with high quality aquifer protection would cost an estimated $2,170 and $2,770 per lineal foot, respectively.

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[1] MSDGC, January 1975.

[2] All cost figures presented in this section are based on 1972 values.

The tunnel costs estimated above include the following base figures:

- Cost of muck disposal, estimated to be $4.00 per solid cubic yard
- Nominal grouting[1] for control of infiltration during construction, estimated to be $0.30 per square foot of tunnel wall
- Access and ventilation shaft construction
- Ventilation and hoist equipment
- Grout and grout inspection equipment
- Average aquifer protection costs.

Additional grouting for aquifer protection in unlined tunnel segments in the upper aquifers is estimated to cost $1.50 per square foot of tunnel wall. This grouting would be provided to a depth of about one tunnel diameter beyond the excavated tunnel limit.

The total construction cost for all the TARP tunnel systems is approximately $567 million. The estimated total costs for the subsystems are: $93 million for collecting/connecting structures, and $38 million for pumping stations. These subsystem costs are based on the following:

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[1] Grouting is a procedure whereby a mixture of cement and water is injected under pressure into a drilled hole that intersects a source of seepage such as an open joint, fault, or bedding plane.

- **Collecting Structures and Connecting Lines.** The cost of the near-surface collection structures leading to the drop shafts includes the gravity interceptor sewers and the necessary connecting structures. Table III-1 lists the costs for these subsystems with respect to the TARP tunnel systems.

Table III-1
Estimated Costs For
Collecting Structures and Connecting Lines

Tunnel System	Estimated Cost ($ Million)		
	Intercepting Structures	Collection System	Total
Mainstream	8.701	3.648	12.349
Calumet	1.084	1.088	2.172
Lower and Upper Des Plaines	1.043	3.489	4.532
TOTALS	10.828	8.225	19.053

- **Drop Shafts.** The estimated cost of drop shafts includes all drop shaft components. The costs are related to the shaft diameter and to the depth of penetration into the rock formations. The cost of 250-foot deep drop shafts varies from $80,000 for a shaft two feet in diameter to $1,400,000 for a 20-foot diameter shaft. Continued development of the "raise-bore" machines could reduce the cost of shafts in rock by reducing excavation costs and by eliminating concrete linings.

- **Pumping Stations.** The estimated construction cost of pumping facilities includes the structure, pumping equipment, power generation for the operation of larger units, and discharge piping to the appropriate treatment plant. The estimates have been based on use of variable-speed, motor-driven units. Total capital costs for pumping vary as follows:

Lift Height	Estimated Cost ($ Million) Pumping Capacity 1000 cfs	 100,000 cfs
300 feet	5.6	200
525 feet	5.7	300

3.7 TARP FINANCING

Financing of the entire $3.54 billion MSDGC Flood and Pollution Control Plan over the next 11 years is doubtful. As illustrated in Table III-2, however, the financing requirements for all conveyance tunnels could be met by a modest increase in Federal and MSDGC funding over a period of 11 years, from 1976-1986. An additional $220.0 million appropriation of Federal funds and an additional $73.5 million of MSDGC funds are estimated to be required to finance the three (Mainstream, Calumet, and Lower Des Plaines) TARP tunnel systems. The additional Federal funds represent a modest portion (28.3 percent) of the conservatively estimated $780 million of new PL 92-500 money which is expected to be forthcoming to MSDGC over the next six fiscal years. Congress, however, has not yet approved any additional appropriation beyond the initial $18 billion which was authorized under PL 92-500 and totally allocated over the FY 1972-1976 period. The $73.5 million of MSDGC funds represents an increase of about 19 percent over the current MSDGC bonding authorization. This amount, however, represents a very modest proportion of the additional $200-400 million bonding authorization for which MSDGC is currently formulating plans to ask the State of Illinois.

If the tunnel phase of TARP is not implemented, there is a very high probability that approximately 90 percent of the currently available Federal funds assigned to the MSDGC will be lost by both the State of Illinois and the MSDGC. This potential loss to the MSDGC and state stems from the fact that the Calumet and North-Side treatment facilities expansion project, (which represent the next major projects in terms of priority for Federal funds) will not meet the September 30, 1977 deadline for Step 3 funding eligibility. Assuming these two projects did not qualify in time for existing Federal funds, it is estimated that only approximately 10 percent of the $323.6 million could alternatively be allocated to other MSDGC or statewide prioritized pollution control projects.

The financing feasibility of other key elements (non-TARP) of the MSDGC's Flood and Pollution Control Plan (see Table III-2), which are closely related to the overall goal of meeting the 1983 water quality standards, ranges from almost certainty to near zero. Addressing these elements in the order of priority specified in the MSDGC's 1975 Facilities Plan, instream aeration stands next in line behind the conveyance tunnels. The approximately $16.7 million required for instream aeration can easily be met from

Table III-2
Financing Schedule - Phase I Tunnel System and Other Non-TARP Elements of the MSDGC Pollution Control Plan

Priority List of Projects	Estimated Costs[1]	EPA			STATE OF ILLINOIS			MSDGC			COE		
		Currently Available[2]	Currently Projected[3]	Additionally Required[4]	Currently Available[5]	Currently Projected	Additionally Required	Currently Available[6]	Currently Projected[7]	Additionally Required	Currently Available[8]	Currently Projected[9]	Additionally Required
1. Conveyance Tunnels	1,032.4	372.6[10]	220.0	0.0	300.0	0.0	0.0	66.3	73.5	0.0	0.0	0.0	0.0
2. Instream Aeration	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0
3. Treatment Plant Upgrading[11]	1,019.1	0.0	560.0	166.2	0.0	0.0	0.0	0.0	0.0-254.8	0.0-166.6[1]	0.0	0.0	0.0
a) Calumet	352.8	0.0	264.6	0.0	0.0	0.0	0.0	0.0	88.2	0.0	0.0	0.0	0.0
b) West-Southwest	666.3	0.0	181.2	166.2	0.0	0.0	0.0	0.0	0.0-166.6	0.0-166.6	0.0	0.0	0.0
4. Reservoirs and Flood Control	810.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	810.1
Total[12]	2878.3	372.6	780.0	166.2	300.0	0.0	0.0	66.3	90.2-345.0	0.0-166.6[1]	0.0	0.0	810.1

FOOTNOTES

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1 All cost estimates are based on those presented in the MSDGC's Facilities Planning Study (January 1975) and are escalated 6 percent annually for inflation.

2 These funds represent the remainder of the FY 1975 and FY 1976 PL 92-500 appropriation which are expected to be allocated to MSDGC by the State.

3 These are Federal funds, above and beyond the existing PL 92-500 appropriation, which are expected (in the form of a new appropriation) over the period FY 1977-1982.

4 These are Federal funds above and beyond the additional $780 million expected over the FY 1977-1982 period.

5 These are funds, under the State's current $750 million bonding authorization, which are expected to be available to MSDGC to finance the Tunnel Plan.

6 The funds in this category represented those available by virtue of the unused bonding authority of the MSDGC under the current $380 authorization.

7 This category represents funds expected to be available under an additional $200 to $400 million bonding authority for which the MSDGC is currently formulating plans to ask the State of Illinois.

8 There is no current COE appropriation for any MSDGC Flood and Pollution Control Plan elements.

9 There is no near future COE appropriation expected for any MSDGC Flood and Pollution Control Plan elements.

10 Includes approximately $49.6 million already obligated to the North Shore section of the Mainstream Tunnel Plan (Addison-Wilmette segment).

11 Figure doesn't include the estimated $124 million already obligated for the O'hare treatment plant project.

12 The total estimated cost $3030.6 million differs from the $3536.5 million (Table III-10 of the main body of the EIS) because of the exclusion of the following projects: sewers, solids disposal, O'hare Treatment plant, and food control(non-TARP).

existing state and MSDGC funding sources. It is very unlikely, however, that the financing will be available to increase the treatment levels, efficiencies, and capacities at all the treatment plants (Northside, Calumet, and West-Southwest). The total required financing ($1.02 billion) would necessitate a significant increase above the additional levels of Federal ($780 million) and MSDGC ($200-400 million) funds expected to be available over the FY 1977-1986 timeframe. The financing feasibility of the Calumet treatment plant expansions, however, is reasonable in view of their combined total estimated costs of $352.8 million. The Federal funding portion ($264.6 million) could be provided from the additional $780 million PL 92-500 appropriation expected over the next six years. The MSDGC portion ($88.2 million) could be provided from the anticipated $200-400 million additional bonding authorization.[1] In terms of the West-Southwest treatment plant expansion project (estimated cost of $666.3 million), the financing feasibility is very questionable in view of the requirement for additional funds beyond the levels (Federal and MSDGC) expected to be available over the period FY 1977 to 1986.

The operation and maintenance costs of the TARP tunnel systems will be financed by a user charge system rather than the current ad valorem tax system. PL 92-500 requires the development of a user charge system and the State of Illinois presently has the authority to impose a user charge. This system of financing the annual operations and maintenance costs of the tunnel systems is not expected to have a significant economic impact in the commercial, industrial, and household sectors. The incremental charge in the MSDGC tax rate per $100 of assessed valuation (1975 rate was $.4005) is estimated to be $.0541 (for operations and maintenance) and $.0532 (for tunnel construction) by the year 1986. The tunnel construction impact will continually decline after 1986 with the continuing growth of the tax base. Details of this financial system are provided in the EIS in Sections 3.3.1 and 9.3.

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[1] However, to provide the $126.3 million, the MSDGC's additional bonding authorization must be at least $216.5 million.

IV. PRINCIPAL FINDINGS CONCERNING THE EFFECTS OF THE PROPOSED ACTION

Chapters VI through IX of the EIS assess the beneficial and adverse effects of the construction and operation of the conveyance tunnel systems on greater Chicago's natural and man-made environments. This chapter presents the principal findings of that analysis only for those effects expected to be relatively significant.

The most significant finding relates to the expected improvement in water quality resulting from the operation of the three tunnel systems. To assess the significance of this improvement the EIS considers the possible and likely cumulative effects of other components of TARP which are not directly the subject of this EIS. These other components are the reservoirs, treatment plant improvements, and instream aeration. The environmental effects associated with these components were not otherwise assessed in this EIS.

The principal findings of the EIS are presented under the following subsections:

(1) Effects of Operation on Water Quality

(2) Effects of a Significant Earthquake on Tunnel System

(3) Effects of Shale Deterioration on Tunnel Stability

(4) Effects of Rock Spoil Generated During Construction

(5) General Effects of Construction

(6) Effects of Infiltration and Exfiltration

(7) Worker Safety During Construction

(8) Effects of Operation on Land Use

(9) Effects of Construction on Employment.

(1) Effects of Operation on Water Quality

THE TUNNEL WILL SIGNIFICANTLY REDUCE THE POLLUTANT LOAD CURRENTLY DISCHARGED TO CHICAGO'S WATERWAYS, HOWEVER, THE TUNNELS ALONE WILL NOT RESULT IN ATTAINING APPLICABLE ILLINOIS WATER QUALITY STANDARDS, AND, THEREFORE, WILL NOT ENABLE ADDITIONAL USES OF THE AFFECTED WATERWAYS. THE ATTAINMENT OF ILLINOIS WATER QUALITY STANDARDS DEPENDS ON ADDITIONAL CONTROL MEASURES FOR WHICH THE FUNDING PROSPECTS ARE NOW POOR.

This conclusions is based on the following findings:

- The tunnels will capture approximately 90 percent of the pollutant load now discharged during combined-sewer overflows and will reduce the pollutant load 75 percent overall and the frequency of overflows from 100 to 10 times per year. 1977 Illinois water quality standards will continue to be violated during overflow events because of uncontrolled injections of pollutants into the waterways.

- The tunnels may not result in the attainment of 1977 Illinois standards for ammonia over lengthy reaches of waterway, because high concentrations of this pollutant are discharged from local wastewater treatment plants. Although data is not presently available to allow a more definitive determination of effects on this point, the attainment of water quality standards in the area's major river systems is clearly and intimately tied to the upgrading and expansion of MSDGC treatment plants.

- With the tunnels on line, 1977 Illinois standards of 4 mg/l for dissolved oxygen (DO) will still be violated along approximately 50 of the 80 miles of the Main Channel and of the Calumet River systems during the critical late summer months. Conditions along the Des Plaines River system have not yet been modeled by the MSDGC, but will be completed under the Section 208 planning program.

- Implementation of the reservoirs in addition to the TARP tunnel systems will effectively eliminate combined-sewer overflows to surface waterways, thus averting violations of water quality standards due to wet weather conditions. However, the combination of tunnels and reservoirs will still not enable attainment of the 1977 DO standard over roughly 40 of the 80 miles of waterways during the late summer months.

- Implementation of the tunnels and reservoirs in conjunction with upgrading of treatment plants is projected to have a beneficial effect on DO concentrations, but the combination will still fail to meet 1977 Illinois standards along approximately 24 of the 80 miles of waterways modeled. The time period will be the same as previously stated.

- 1977 Illinois standards for DO are likely to be met over the entire 80-mile length of the modeled waterways during critical summer dry flow conditions, assuming implementation of the following pollution control components:

    - Tunnels
    - Reservoirs
    - Treatment plant improvements
    - Instream aeration.

- The water quality impact of these various pollution control options is summarized in Table IV-1.

- Given current projections of Federal, State, and MSDGC financing capabilities and policies, the financing of the tunnels and instream aeration appears secure. The financing of the Calumet and North-Side treatment plant expansions is probable; but financing the costly West-Southwest treatment plant is very doubtful. The financing of the reservoirs in the near future is very unlikely given the absence of any Federal commitment to provide assistance.

Additional details on water quality are provided in Sections 2.1 and 8.1 of the EIS text and details on financing in Section 3.3.1.

Table IV-1
Impact of Potential Pollution Control Options on Water Quality Along Main Channel and Calumet River Systems[1]

Notes (a) Tunnels plus instream aeration effects addressed in Section 8.1.1 of EIS.
(b) Phasing of options shown in order adopted by MSDGC in modeling studies.

Pollution Control Option Water Quality Component	No Action	Phase I Tunnels	Phase I Tunnels Plus Instream Aeration	Tunnels Plus Treatment Plant Upgrading[2] Plus Instream Aeration	Tunnels Plus Reservoirs Plus Treatment Plant Upgrading Plus Instream Aeration
Combined-Sewer Overflows	Overflow to waterways 100 times per year. Illinois standards violated most of the time.	Overflows reduced from 100 to 10 per year. 75 percent of pollutant load captured and treated.	No significant change	No significant change	No significant change
Ammonia and Phosphorus Levels	Ammonia standard violated by treatment plant discharges; phosphorus standard violated during overflow.	Ammonia and (possibly) phosphorus standards violated due to treatment plant discharges.	No significant change	Ammonia and phosphorus standards met most of the time (not during overflow episodes).	Ammonia levels in waterways improved beyond standard, phosphorus standard met.
Dissolved Oxygen (DO) Concentrations[3]	DO levels below Illinois standards along 80 percent of waterways. Anaerobic conditions exist over large stretches.	DO levels below Illinois standards along 70 percent of waterway. Anaerobic conditions greatly relieved.	Resulting change in DO levels not known	Resulting change in DO levels not known	Illinois standard met over entire 80-mile length of waterway. Anerobic conditions completely eliminated.
Allowable Water Uses	Illinois water use standards not met along area waterways.	No significant change	No significant change	No significant change	Illinois water use standards met. Fishing, boating, and shoreline activities permitted.

[1] Computer simulations of water quality along the Des Plaines River not yet available.

[2] Upgrading to tertiary level assumed with nitrogen and phosphorus removal.

[3] Evaluated for dry weather flow conditions.

[4] Computer simulations of dry weather flow conditions.

(2) Effects of a Significant Earthquake on Tunnel System

IF A SIGNIFICANT EARTHQUAKE OCCURS IN THE CHICAGO AREA, THE EVENT MAY OFFSET TUNNEL ALIGNMENT AND CAUSE SIGNIFICANT DAMAGE TO PORTIONS OF THE TUNNEL SYSTEM.

This conclusion is based on the following findings:

- The 175-year historical earthquake records indicate that a seismic event with a Modified Mercalli Intensity (MMI) of VIII can recur in the Chicago area at a rate of about once per 100 years. Assuming the tunnel system is in operation for 100 years, the probability of this event occurring at some time during this period is 100 to 1 or 10,000 to 1 for any given year. If an MMI VIII event occurs, severe alterations to tunnel alignment or tunnel surface may result.

- The conveyance tunnels will pass through several active faults prevalent in the TARP project area and will be sensitive to earth movement at these locations. Information on the distribution and nature of the active faults is insufficient to assess accurately the extent of damage which could result from an MMI VIIIearthquake.

Further information on this subject may be found in Sections 2.2.3, 2.2.4, and 8.2.2 of the EIS.

(3) Effects of Shale Deterioration on Tunnel Stability

FOR THOSE SEGMENTS OF THE TUNNEL SYSTEM WHICH ENTER SHALE FORMATIONS, TARP CONSTRUCTION AND OPERATION MAY BE AFFECTED BY SHALE DETERIORATION.

This conclusion is based on the following findings:

- Certain sections of the TARP tunnel systems will be aligned within Maquoketa shale. During excavation activities in this rock series, rockfalls and partings (loosened material) will occur and may cause construction delays or safety problems. Delays can range from several weeks to several months and are costly in terms of labor, equipment, injuries, and lost time. The $30 million (1972 base) contingency fund established in the TARP budget is expected to be sufficient to cover the costs of delays.

- Concrete lining is expected to deter, but not fully to eliminate, shale deterioration. Most of the TARP tunnel systems will be concrete-lined and located in Silurian dolomite rock. Short lengths of conveyance tunnel, however, will be in shale formations, and deterioration (i.e., erosion) will occur over a long period of time as a result of water seepage or exfiltration. If deterioration becomes extensive, additional stress will be placed on the lining, and it may cause fracturing or cracking of the lining.

Sections 6.2.2, 8.2.2, and 10.1.2 (2) provides additional information on the subject matter of this finding.

(4) Effects of Rock Spoil Generated During Construction

THE ROCK SPOIL MATERIAL GENERATED DURING TUNNEL CONSTRUCTION IS NOT EXPECTED TO BE MARKETABLE. THEREFORE, ENVIRONMENTAL IMPACTS ASSOCIATED WITH DISPOSAL OF THE ROCK SPOIL WILL DEPEND LARGELY ON THE AVAILABILITY OF LANDFILL DISPOSAL SITES.

Approximately 4,540,000 cubic yards (bulk measure) of spoil will be removed from the Mainstream Tunnel in the 59th Street to Addison Street segment, which is approximately 53 percent of the total removed from the entire Mainstream Tunnel system. Although this amount can be adequately contained within the inactive Stearns quarry, the large quantities of spoil involved in reservoir excavation could complicate disposal plans for tunnel spoil. Disposal of rock spoil from the reservoirs was addressed briefly in Section 6.2.4 of the EIS. A significant portion of rock spoil generated by reservoir construction is likely to be marketable and to be stockpiled on the quarry site for eventual sale by the quarry owners.

Major findings supporting the above conclusions are:

- Shale and other constituents present in the rock excavated from the Phase I tunnels will limit the rock's suitability for low-grade commercial uses.
- Landfill disposal sites capable of accepting the entire volume of tunnel spoil to be generated during TARP Phase I have not yet been identified by the MSDGC.
- The inactive Stearns quarry has enough volume to accept the entire quantity of spoil to be excavated from the Mainstream Tunnel 59th Street to Addison Street segment (53 percent of total Mainstream Tunnel system).
- Since conventional methods will be used to excavate rock from the McCook and Thornton quarries for reservoir construction, it is likely that a significant portion of the spoil will be marketable. Present plans envision stockpiling the saleable portion on the quarry sites for eventual sale by the quarry owners. Various stockpile configurations are being considered. Nonsaleable spoil will be stockpiled either on-site, as is proposed for the McCook quarry site, or at an off-site location owned by the MSDGC, as is proposed for the Thornton quarry material.

A more detailed discussion is provided in Section 6.2.4 of the EIS.

(5) General Effects of Construction

CONSTRUCTION OF THE TARP TUNNEL SYSTEMS WILL RESULT IN TEMPORARY PUBLIC ANNOYANCE AND INCONVENIENCE FROM THE CUMULATIVE EFFECTS OF NOISE, HANDLING OF CONSTRUCTION DEBRIS, VIBRATION FROM BLASTING, DISRUPTION OF VEHICULAR AND PEDESTRIAN TRAFFIC, AND GLARE FROM THE ILLUMINATION OF CONSTRUCTION AREAS AT NIGHT. ALTHOUGH THE CUMULATIVE EFFECTS MAY BE NOTICEABLE, TAKEN SINGLY, EACH EFFECT IS MINOR.

This conclusion is supported by the following findings:

- Surface construction sites are located in areas which are generally either vacant or near low-utilized industrial land.

- Noise at each construction site should be within levels mandated by Chicago ordinances and, at each surface construction site, noise will only occur for periods of three to nine months.

- Because blasting will be used only to excavate shafts and not the tunnel, itself, blasts will be relatively infrequent and will continue at any one site for not more than 120 days.

Further information on this subject may be found in Sections 6.3.1, 6.3.2, 7.1.1, 7.2.1, 7.4, and 10.2.

(6) Effects of Infiltration and Exfiltration

IF THE GROUTING PROGRAM IS NOT EFFECTIVE,[1] GROUNDWATER INFILTRATION DURING CONSTRUCTION AND WASTEWATER EXFILTRATION DURING TUNNEL OPERATION CAN BE A SIGNIFICANT PROBLEM.

This conclusion is supported by the following findings:

- The inflow rate of groundwater for the TARP tunnel systems is estimated to be an average of approximately 0.5 MGD per mile of tunnel. In the absence of appropriate mitigative measures, this rate is sufficient to lower the piezometric or hydraulic pressure level of the upper aquifer. Tunnel grouting is the most effective method to reduce infiltration and a grouting program has been incorporated in TARP. Grouting integrity, however, must be maintained to keep inflows below the allowable limit of 500 gallons per day per inch of tunnel diameter per mile of tunnel. Observation wells will be required to monitor integrity throughout the operational phase of the tunnel.

---

[1] The objective of grouting is to achieve maximum penetration and a uniform grout spread. If grouting is ineffective, maximum [illegible]tration/exfiltration flows will result.

- Exfiltration will most likely occur when tunnel pressures exceed inflow pressures during high storm runoff conditions. The TARP grouting program is expected to prevent extensive exfiltration of tunnel wastewaters into the upper aquifer. However, if grouting integrity is not maintained during tunnel operation, exfiltration will be at a high enough rate to degrade groundwater quality of the upper aquifer. Observation wells will be necessary to determine whether exfiltration is occurring along the tunnel routes.

EIS Sections 2.1.2, 6.1.2, and 8.1.2 provide more information on the subject of groundwater infiltration and wastewater exfiltration. Specifications for observation well spacing and for the monitoring program are also presented in these sections.

(7) Worker Safety During Construction

TUNNEL OR UNDERGROUND CONSTRUCTION WORKERS WILL BE MORE SUSCEPTIBLE TO INJURY, DISABILITY, AND FATALITY THAN SURFACE CONSTRUCTION WORKERS. THE INCIDENCE OF INJURIES AND FATALITIES, HOWEVER, IS NOT EXPECTED TO BE GREATER THAN NORMAL FOR THIS TYPE OF CONSTRUCTION WORK.

This conclusion is supported by the following findings:

- Based on recent national statistics for all types of construction activities, the Mainstream Tunnel system construction may result in 90 disabling injuries and in one permanent disability or fatality. For construction of the entire tunnel system, injuries and fatalities are expected to increase proportionately.

- Based on the safety statistics of the current construction of a rapid-transit system subway in Washington, D.C., construction of the entire TARP tunnel system could result in 1,829 injuries and in 11 fatalities.

- Analysis of the geologic and seismic characteristics of the project area indicates that most of the area is stable and suitable for the construction of underground tunnels. Precautionary measures will be required to protect workers in segments where rockfall and partings (loosened material) may occur frequently and shale deterioration conditions prevail.

Further information on this subject may be found in Sections 6.2.2 and 7.1.2.

(8) Effects of Operation on Land Use

THE QUALITY OF LAND IN CERTAIN RIVERBANK SECTIONS ALONG THE 59TH-TO-ADDISON MAINSTREAM TUNNEL ROUTE MAY BE ENHANCED BY REDUCED FLOODING CONDITIONS.

Vacant land exists between the North Branch-Chicago River and North Leavitt Street (bounded by West Oakdale Avenue on the north and North Hoyne Avenue on the south) in a residential area. The reduction of flooding in this area may enable development of this under-utilized land into open space uses such as: parks, playgrounds, sport fields, and parking areas.

(9) Effects of Construction on Employment

CONSTRUCTION OF THE MAINSTREAM TUNNEL WILL PROVIDE OVER $87 MILLION IN CONSTRUCTION INCOME OVER A SEVEN-YEAR PERIOD AND WILL CREATE A PEAK SUPPLY OF APPROXIMATELY 800 JOBS OVER A THREE-YEAR PERIOD.

Further information may be found in Section 7.1.3.

(10) Funding Uncertainty for TARP

THE CONVEYANCE TUNNELS CAN BE FINANCED BETWEEN 1976-1987 WITH MODEST INCREASES IN ANTICIPATED FEDERAL AND LOCAL FUNDING. HOWEVER, THE FUNDING OF THE RESERVOIR DURING THIS TIME PERIOD IS NOT A PART OF THE CURRENT FINANCING PLAN AND COULD NOT BE ACCOMPLISHED WITHOUT HAVING A MAJOR FINANCIAL IMPACT ON THE STATE, CITY, OR MSDGC.

Additional details on this finding may be found in Section 3.3.1 of the EIS.

(11) Effects of Flooding on Lake Michigan

THE FLOODING PROBLEM EXISTING IN THE CHICAGO AREA WILL NOT BE RESOLVED BY THE PHASE I TUNNELS. OVERFLOW TO LAKE MICHIGAN WILL STILL PERSIST IF THE PROPOSED RESERVOIRS ARE NOT IMPLEMENTED.

V. CONCLUSIONS AND RECOMMENDATIONS

The following is a summary of the principle conclusions of the Draft EIS, as well as recommended and suggested mitigative measures.

1. Implementation of the Mainstream Tunnel system will significantly reduce the pollutant load in the Chicago waterways. These loadings will be reduced further with the implementation of the Calumet and lower Des Plaines Tunnel systems. Water quality will be enhanced further with the upgrading of MSDGC's treatment facilities and the construction of the flood control aspects of the Tunnel and Reservoir Plan.

2. Significant earthquake events could adversely affect tunnel alignment and tunnel lining. Smaller earth movements could also affect the lining and grouting of the tunnels. It is, therefore, essential that MSDGC's inspection and maintenance program be extensive enough to insure efficient operation of the system.

3. Rock falls and partings may occur particularly in shale formations during construction. Stabilizing measures such as rock bolting are proposed to mitigate the short-term construction problems, while concrete lining will be utilized for the long term. Even with these measures, shale deterioration will continue and the inspection program should take these sensitive areas into account.

4. The rock spoil excavated from the Phase I tunnels is not expected to be marketable. Evaluation of various disposal alternatives leads to the conclusion that adequate environmentally acceptable landfill sites are available to handle the volume of rock which will be generated by the Phase I tunnels under consideration. We will rely on existing local, state, and Federal regulations to insure that disposal takes place in an acceptable manner.

5. Although an effective grouting program is proposed, it must be sufficiently flexible to respond to the actual conditions encountered during construction. Should the grouting not be sufficient, additional infiltration could adversely affect the hydraulic pressure of the upper aquifer.

Additionally, under surcharged conditions, exfiltration will occur, resulting in adverse impacts on the groundwater quality of the upper aquifer. Observation wells to monitor grouting integrity during operation are necessary along the entire tunnel alignment. An adequate number of wells are already in existence for the Mainstream Tunnel system. If pollutants are detected in the observation wells, additional mitigative measures must be implemented to protect the upper aquifer, including a groundwater recharge system. Chapter X discussed particular aspects of the monitoring program.

6. Since the majority of the construction shafts and drop shafts are in close proximity to area waterways, runoff from these sites could adversely affect water quality. Berms will be constructed around stockpiles of construction materials and spoil materials to preclude runoff into the waterways.

7. It is presently proposed that water pumped from the tunnels during construction be discharged directly to the waterways after a period of settling. Since the possibility of silt and other pollutants still exists after settling, it is recommended that these dewatering flows be discharged to MSDGC's intercepting system for treatment.

8. Although no known historic, architectural, or archaeological resources will be affected by the proposed project, the possibility of finding archaeological resources must be investigated by the MSDGC. This must be accomplished by contacting the State Historic Preservation Officer.

9. Conformance with applicable regulation of the Occupational Health and Safety Administration, U.S. Department of Labor, and the Bureau of Mines, U.S. Department of the Interior is essential for safety of construction workers.

10. A conflict exists between the location of several drop shafts and the plans for the Central Area Transit Project. The MSDGC must meet with the Chicago Urban Transportation District to resolve these conflicts.

11. There exists a wide range of potential adverse impacts which could develop during construction. This includes blasting, waste spillage, traffic congestion, light glare, and fugitive dust at construction and disposal sites. While these effects could be considered insignificant any measures taken to reduce their impact would aid in public acceptability of the project. These suggested mitigative measures are discussed in Chapter X.

DRAFT ENVIRONMENTAL IMPACT STATEMENT

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I. INTRODUCTION

I. INTRODUCTION

1.1 ENVIRONMENTAL POLICIES AND GOALS

In 1969, Congress enacted the National Environmental Policy Act, Public Law 91-190 (NEPA). NEPA established a Council on Environmental Quality (CEQ) and a national policy to:

- Encourage productive and enjoyable harmony between man and his environment
- Promote efforts to prevent or eliminate damage to the environment and stimulate public health and welfare
- Enrich man's understanding of ecological systems and of the Nation's natural resources.

NEPA states that the Federal Government will have the continuing responsibility of improving and coordinating Federal actions (i.e., plans, programs, resources, and functions) which affect environmental, resource, and health quality. NEPA further states that all Federal agencies are required to "... utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment ..." Federal agencies are also required to investigate and develop procedures and technology to evaluate unquantifiable environmental amenities and values and give them appropriate consideration, in addition to quantifiable technical and economic factors.

The U.S. Environmental Protection Agency (EPA) is administering a major Federal environmental program entitled "Grants for Construction of Treatment Works."[1] This program allows the EPA administrator to provide financial aid to any state, municipality, intermunicipal agency, or interstate agency for the construction of publicly owned water pollution control facilities. The program will encourage reduction of point sources of water pollution to improve national water quality.

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[1] Authorized by Title II, Section 201(g)(1), of the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (FWPCA).

1.2 ENVIRONMENTAL IMPACT STATEMENTS

Pursuant to Section 102(2)(c) of NEPA, all Federal agencies are required to prepare environmental impact statements (EIS) for those actions significantly impacting the human environment. On August 1, 1973, the CEQ published guidelines[1] on the preparation of an EIS to instruct agencies in meeting NEPA requirements. The EPA subsequently published its own regulations[2] for the preparation of an EIS. The regulations specify minimum standards to present all pertinent data in a consistent and organized manner, and ask that the facts be presented comprehensively enough to enable the reader to assess the proposed action independently. As stated in both the CEQ and EPA guidelines, the purpose of an EIS is to provide a means of assessing impacts on the environment and not to provide a justification for decisions made.

The EPA's granting of funds for water pollution control facilities may require EISs. Each proposed water pollution control facility is evaluated on a case-by-case basis by the appropriate EPA regional office to determine whether an EIS is required. Generally, an EIS is required if the action is expected to have significant environmental effects or if it is highly controversial. The EPA has prepared this EIS because it expects the environmental effects of the tunnel system to be significant.

An EIS usually presents only the information necessary to address fully the specific environmental issues of the action. It focuses on the critical issues and only summarizes the less critical issues. An overview of the contents of a typical EIS is presented in Figure I-1 as a flow scheme. The scheme illustrates the approach normally used for systematic gathering and processing of information during document preparation. Initially, a draft statement is

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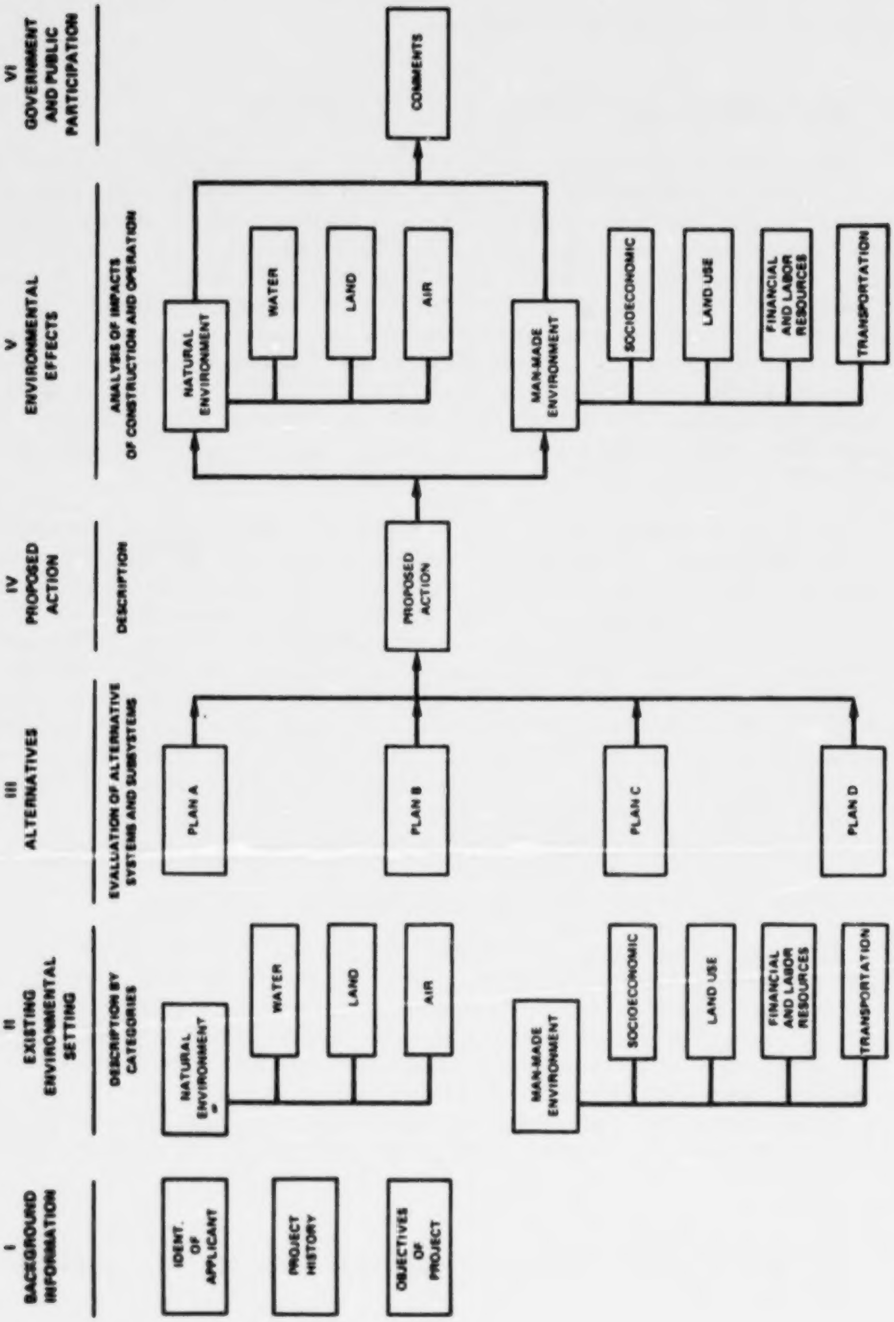
[1] Title 40, Code of Federal Regulations (CFR), Chapter V, Part 1500.

[2] Title 40, CFR, Chapter I, Part 6.

FIGURE I-1
Flow Scheme of EIS Contents


I
BACKGROUND INFORMATION
IDENT. OF APPLICANT
PROJECT HISTORY
OBJECTIVES OF PROJECT
II
EXISTING ENVIRONMENTAL SETTING
DESCRIPTION BY CATEGORIES
NATURAL ENVIRONMENT
WATER
LAND
AIR
MAN-MADE ENVIRONMENT
SOCIOECONOMIC
LAND USE
FINANCIAL AND LABOR RESOURCES
TRANSPORTATION
III
ALTERNATIVES
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PLAN A
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LAND USE
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TRANSPORTATION
VI
GOVERNMENT AND PUBLIC PARTICIPATION
COMMENTS

prepared and circulated for comment, and, upon completion of the comment period, the final statement is prepared and issued to all agencies, organizations, and individuals affected by the proposed action.

1.3 GOVERNMENT AND PUBLIC PARTICIPATION

The draft EIS must satisfy, to the fullest extent possible, the requirements established for the final EIS as set forth in Section 102(2)(c) of NEPA. Once completed, the draft statement is distributed for comment, as early as possible, in accordance with the CEQ guidelines. Decisionmakers and outside reviewers are allowed at least 45 days for a thorough review of the environmental issues as described in the draft statement. Comments from Federal, state, and local agencies with jurisdiction by law or with special expertise in environmental impacts are solicited and considered in the impact statement process. In addition, comments are solicited from public and private sources.

Although every effort is made to define and evaluate all the major environmental effects of the proposed action in the draft statement, the commenting process often results in the identification of additional environmental effects, relevant facts, and different viewpoints. When previously overlooked issues and opposing views are brought to the attention of the agency preparing the EIS, the agency addresses them in the final environmental statement. All substantive comments received on the draft EIS are included as an attachment to the final EIS, whether or not the comments merit individual discussion by the agency in the EIS text.

1.4 IDENTIFICATION OF THE APPLICANT

The Metropolitan Sanitary District of Greater Chicago (MSDGC) is the construction grant applicant for the Tunnel and Reservoir Plan (TARP) addressed by this EIS. The District presently covers an area of approximately 860 square miles within Cook County, Illinois, as shown in Figure I-2. The MSDGC was organized in 1889 under an act to create sanitary districts to remove obstructions in the Des Plaines and Illinois Rivers.[1] Under the provisions of the act, the MSDGC

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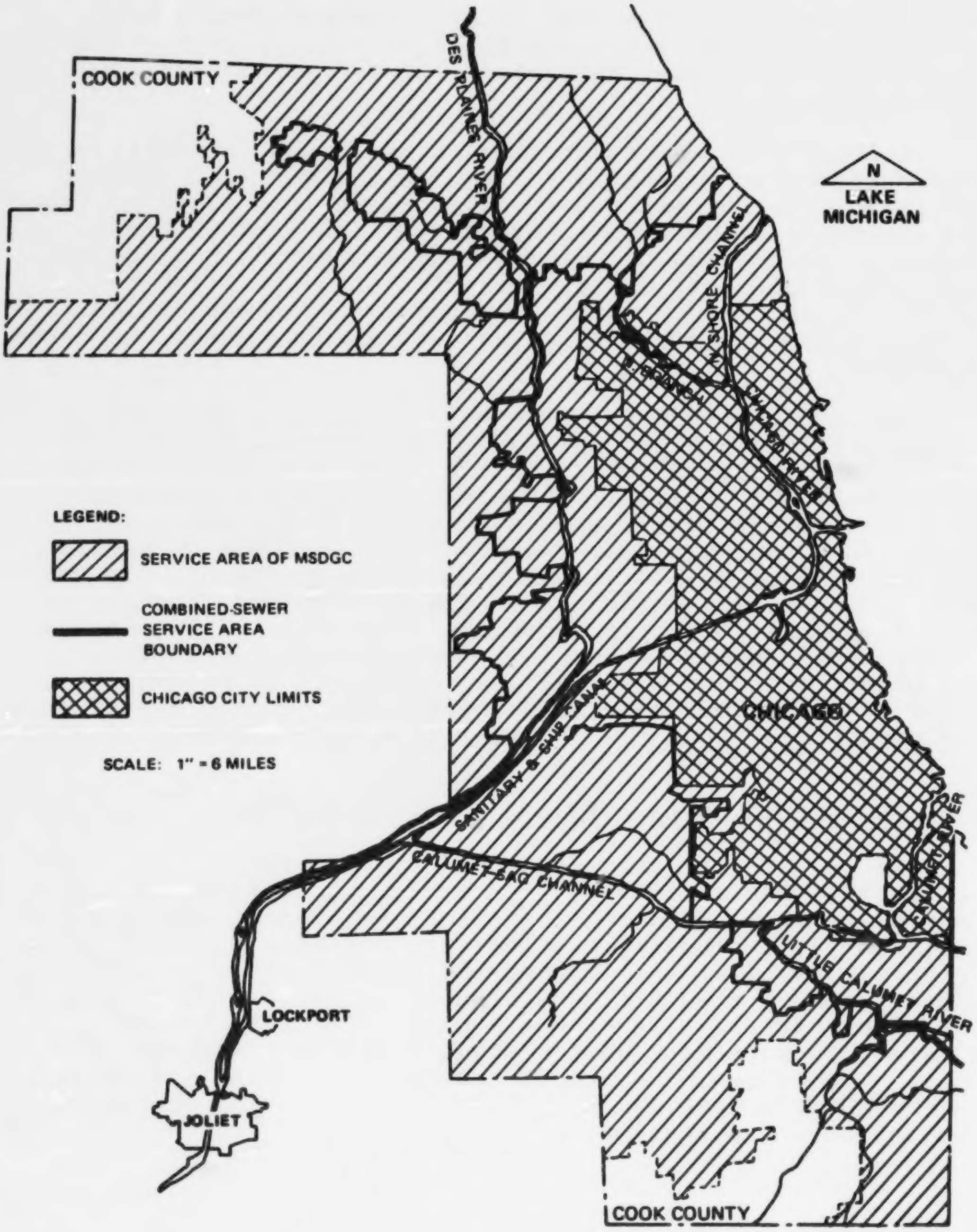
[1] Illinois Revised Statutes, Chapter 42, Section 320, approved May 29, 1889.

FIGURE I-2
Metropolitan Sanitary
District of Greater Chicago
Service Area


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
N. SHORE CHANNEL
N. BRANCH
CHICAGO RIVER
LEGEND:
SERVICE AREA OF MSDGC
COMBINED-SEWER SERVICE AREA BOUNDARY
CHICAGO CITY LIMITS
SCALE: 1" = 6 MILES
CHICAGO
SANITARY & SHIP CANAL
CALUMET-SAG CHANNEL
CALUMET RIVER
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY

is responsible for providing surface water and sewage drainage within the District's boundaries, which it does by constructing necessary facilities, conveyance systems, and treatment plants. The MSDGC is authorized to treat wastewater, either totally or partially, from any municipality within its designated jurisdiction, as well as to own and operate all wastewater facilities located within the MSDGC jurisdiction.

Although the major function of the MSDGC is planning, construction, and operation of sewers and sewage treatment facilities, the District also oversees various flood control and electrical generation operations. Other MSDGC functions involve: purchasing or leasing real and personal property, both within and outside its jurisdiction; initiating condemnation proceedings within its service area boundaries; approving sewer connection plans; and issuing water discharge permits.

The MSDGC presently collects, treats, and disposes of wastewater from a highly urbanized and industrialized area of 120 municipalities which have a total population of approximately 5.5 million. The District owns and operates 70.5 miles of navigable canals, 6 wastewater treatment plants, and approximately 440 miles of intercepting sewers. The three major plants (North-Side, West-Southwest, and Calumet) in the MSDGC service area have a secondary capacity of over 1,750 million gallons per day (MGD). The remaining plants have a combined tertiary capacity of over 10 MGD. A new plant, the John Egan Reclamation Plant, is presently under construction and will be operational in the near future. The capacity of this new plant will be approximately 30 MGD.

1.5 BACKGROUND INFORMATION AND PROJECT HISTORY

The MSDGC initiated its wastewater facilities planning study in September 1967, with a ten-year clean-up and flood control program. The objectives of the program are to solve the District's flooding problem, protect Lake Michigan from further pollution, and improve the water quality of rivers and streams in the Chicago metropolitan area. The Tunnel and Reservoir Plan (TARP) has evolved from this ten-year program, as have most of the MSDGC's planning efforts to date. The following sections present background information on the MSDGC's TARP planning effort and describe the events leading to its selection.

1.5.1 Background Information

The MSDGC service area is approximately 860 square miles, as stated in Section 1.4. Approximately 44 percent of this area, or 375 square miles, is served by MSDGC-owned combined-sewer systems (see Figure I-2) in which wastewater or sewage collected in local sewer systems is conveyed to treatment plants. These combined-sewer systems can handle only industrial, commercial, and household wastewater at the present time, and, if a significant amount of urban runoff enters the systems during wet weather conditions, the capacity can easily be exceeded. Once this occurs, the pollutant-laden runoff bypasses or overflows to adjacent streams. Overflows have occurred on an average of 100 times per year in the Chicago area and have significantly affected the water quality of the streams.[1]

During heavy rain storms, excessive overflows raise the water levels in the region's waterways several feet above normal. The resulting flooding damages private and public property and creates health problems along certain reaches of the waterways. In addition, backflows to Lake Michigan are allowed to help reduce flooding when water levels reach a critical height. Over a thirty-year period, many plans and studies were made to solve the flooding problem, followed, since 1967, by efforts to solve both the flooding and the pollution problems.

1.5.2 Project History

Concerned officials from the State of Illinois, Cook County, the MSDGC, and the city of Chicago reactivated the Flood Control Coordinating Committee (FCCC) in November 1970, to investigate the pollution and flooding problems in the Chicago metropolitan area. The Committee's primary assignment was to develop a viable plan to minimize the area's pollutant discharges and the flooding caused by overflows of mixed sewage and wastewater. Another priority item in the plan was elimination of the need to release polluted river and canal flood waters into Lake Michigan. The Committee's plan was to address the combined-sewer area within Cook County, covering 375 square miles. The location of this area with respect to the surrounding counties is shown in

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[1] The Metropolitan Sanitary District of Greater Chicago, "Environmental Impact Statement," preliminary draft, November 1973.

Figure I-3. The Committee formed a technical advisory committee to develop the plan and to solicit engineers and scientists from government agencies and private consulting firms to assist in the study. Fifty-one alternative solutions were identified to meet water quality standards, to reduce flooding conditions, and to prevent backflows to Lake Michigan. These alternative solutions were analyzed to compare their capital costs, annual maintenance and operation costs, benefits, land acquisition and underground easement requirements, and requirements for relocating residential, commercial, and industrial developments.

The Flood Control Coordinating Committee members evaluated the alternative plans in detail and selected TARP as less costly and more environmentally acceptable than the other plans they evaluated. They initiated additional studies to develop and refine TARP. In October 1972, the final TARP plan was presented at a public meeting conducted by the MSDGC to obtain community and citizen reaction. The following year the MSDGC conducted a public meeting (July 26, 1973) to discuss TARP environmental issues and assessments. Many hearings conducted by Government and local agencies have been held on TARP. A few of the recent hearings include:

- The U.S. Army Corps of Engineers' hearing on the entire tunnel and reservoir plan (November 1975)
- The State of Illinois EPA hearing on the design grants for the first phase tunnels (September 1975)
- The U.S. EPA's hearing on the construction grants for the Wilmette-to-Addison segment of TARP's Mainstream system (July 1975)
- The Northern Illinois Planning Commission's (NIPC) hearing on the TARP facility plans (April 1974).

1.6 OBJECTIVES AND DESCRIPTION OF THE PLAN

The primary objective of TARP is to improve surface water quality within the planning area. The plan is designed to meet water quality standards set forth in the "Water Pollution Regulations of Illinois."[1] These regulatory standards were established for three surface water-use classifications: (1) General (primary body contact), (2) Public and Food Processing (drinking water), and (3) Secondary Body Contact and

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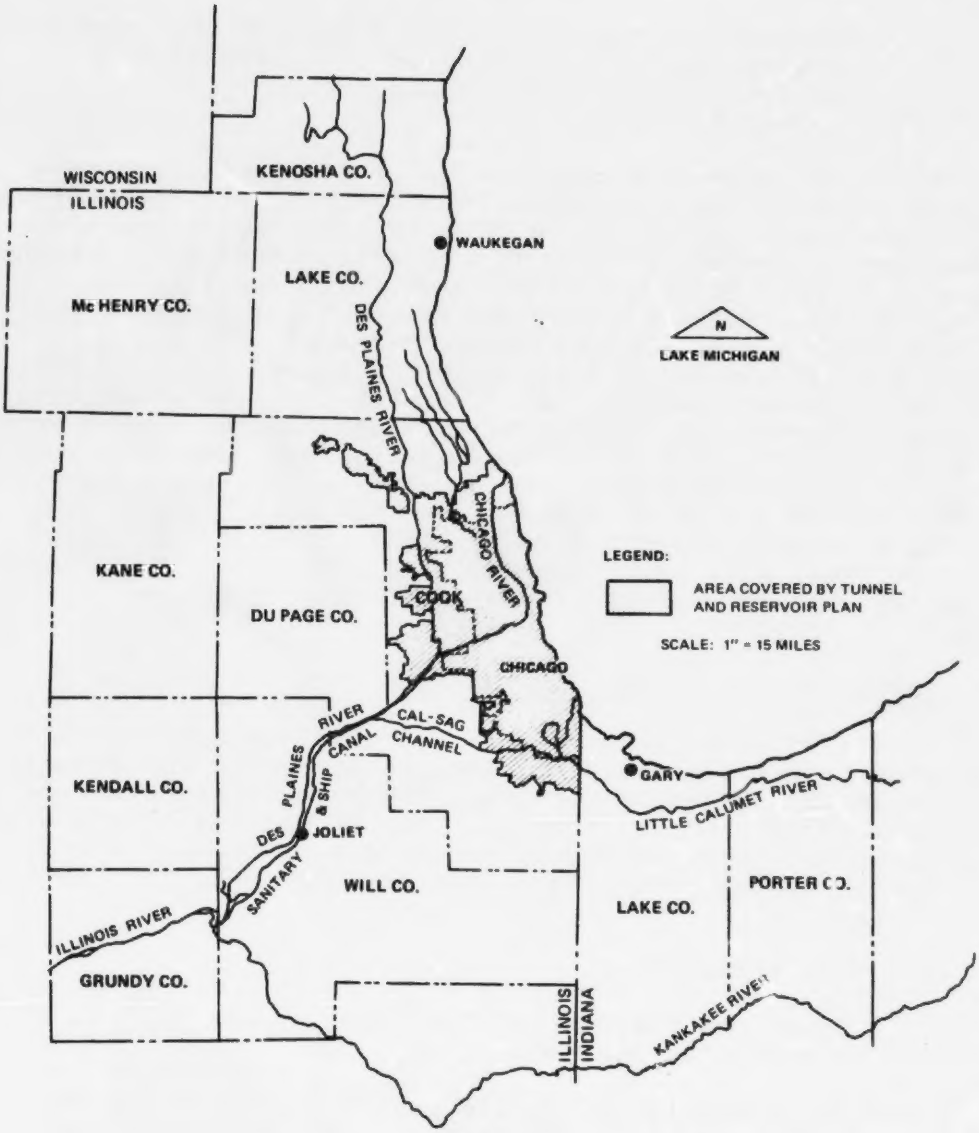
[1] Issued by the Illinois Pollution Control Board (IPCB) on January 31, 1974 (amended).

FIGURE I-3
Planning Area and
Surrounding Counties


WISCONSIN
ILLINOIS
KENOSHA CO.
WAUKEGAN
LAKE CO.
Mc HENRY CO.
DES PLAINES RIVER
LAKE MICHIGAN
N
CHICAGO RIVER
COOK
KANE CO.
DU PAGE CO.
LEGEND:
▨ AREA COVERED BY TUNNEL AND RESERVOIR PLAN
SCALE: 1" = 15 MILES
CHICAGO
RIVER
CAL-SAG
CHANNEL
CANAL
& SHIP
PLAINES
DES
SANITARY
GARY
KENDALL CO.
JOLIET
LITTLE CALUMET RIVER
WILL CO.
LAKE CO.
PORTER CO.
ILLINOIS RIVER
GRUNDY CO.
ILLINOIS
INDIANA
KANKAKEE RIVER

Indigenous Aquatic Life. All surface waters in the State of Illinois have been given a water-use classification by the IPCB and should comply with the appropriate water quality standards. Details of these standards are presented in Chapter II of this EIS. Other important objectives of TARP are to:

- Preserve the health and well-being of the population
- Prevent further pollution of Lake Michigan
- Utilize treated waste byproducts
- Prevent flooding.

The final TARP is a combination of several alternative plans designed to collect urban runoff during all wet weather conditions except those storms of a magnitude equal to the three most severe storms recorded to date by the U.S. Weather Bureau Service. The Plan consists of four tunnel systems, 150 to 290 feet below existing waterways, as shown in Figure I-4, with a total length of approximately 120 miles. Within the 375-square-mile combined-sewer area, urban runoff from 640 existing overflow points and sewage from industrial facilities and residents will be collected in the tunnel systems, conveyed to four treatment plants, and then discharged to the receiving waterways. Three reservoirs are also a part of TARP and have a total water storage capacity of over 130,000 acre-feet. During peak rainfall periods, excessive overflow water will be collected in the reservoirs and stored until dry weather conditions permit adequate treatment.

1.7 ENVIRONMENTAL REVIEWS OF THE PLAN

In view of the potential environmental impacts of TARP, the MSDGC prepared facilities planning documents and several environmental assessment reports. The reports and planning documents pertain to all tunnels, reservoirs, and treatment facilities and their component parts or subsystems. The four TARP tunnel system routes have been designated by the MSDGC as follows:

- Mainstream
- Calumet
- Lower Des Plaines
- O'Hare - Des Plaines.

To obtain environmental approvals and construction grants, the MSDGC submitted the facilities planning documents and environmental reports to the U.S. EPA, U.S. Army Corps of

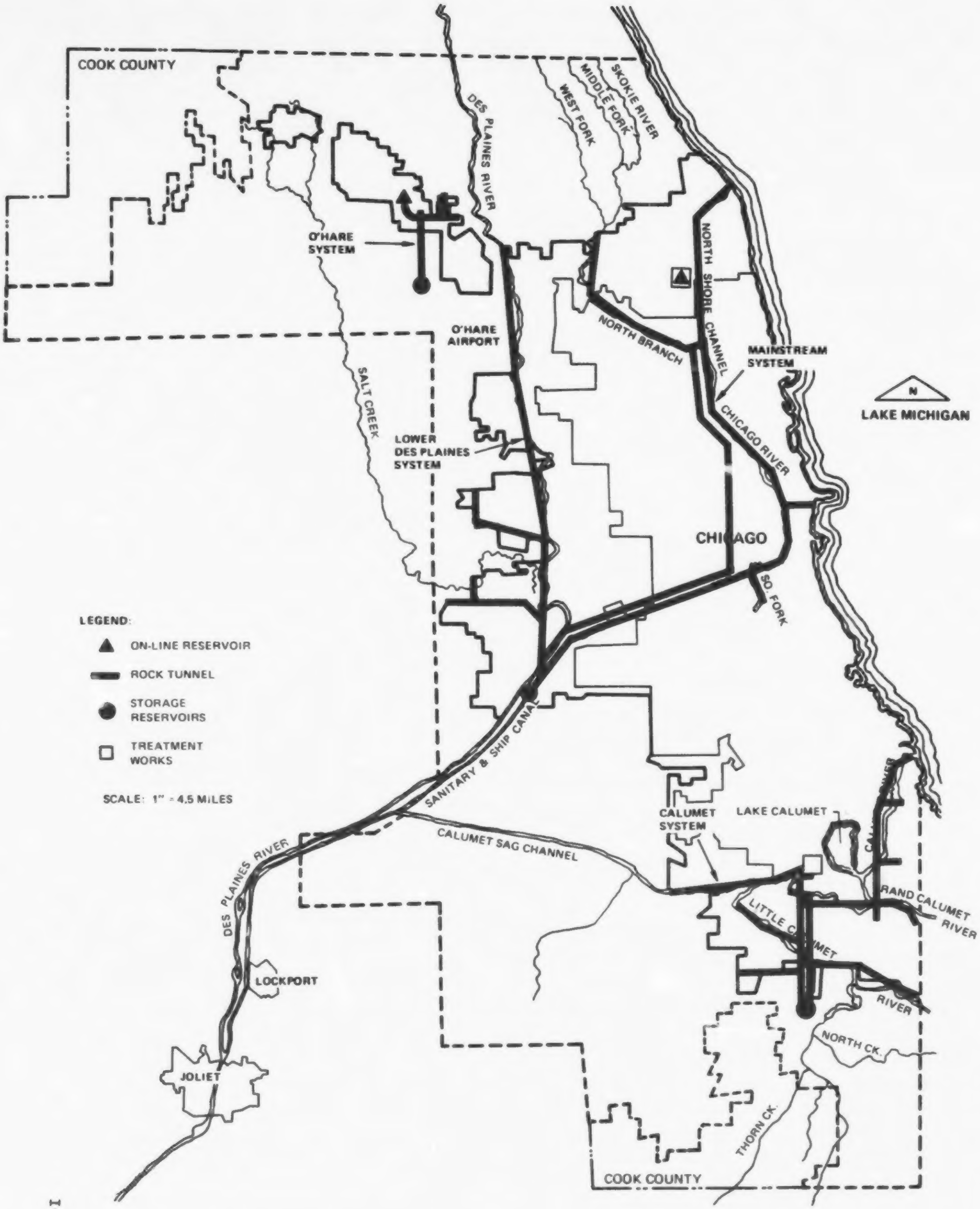

COOK COUNTY
DES PLAINES RIVER
WEST FORK
MIDDLE FORK
SKOKIE RIVER
O'HARE SYSTEM
NORTH SHORE CHANNEL
O'HARE AIRPORT
NORTH BRANCH
MAINSTREAM SYSTEM
SALT CREEK
CHICAGO RIVER
LAKE MICHIGAN
N
LOWER DES PLAINES SYSTEM
CHICAGO
SO. FORK
LEGEND:
ON-LINE RESERVOIR
ROCK TUNNEL
STORAGE RESERVOIRS
TREATMENT WORKS
SCALE: 1" = 4.5 MILES
SANITARY & SHIP CANAL
CALUMET SYSTEM
LAKE CALUMET
CALUMET SAG CHANNEL
DES PLAINES RIVER
GRAND CALUMET RIVER
LITTLE CALUMET RIVER
LOCKPORT
NORTH CK.
JOLIET
THORN CK.
COOK COUNTY

FIGURE I-4
Tunnel and Reservoir Plan

Engineers, and the State of Illinois EPA for review and evaluation. The U.S. EPA review focused on all the pollution control aspects of TARP, while the Corps of Engineers review[1] concentrated on the flood control areas. The Illinois EPA review, however, focused on the design aspects of the Phase I tunnels only.

In accordance with U.S. EPA procedures for determining whether an environmental impact statement is necessary, the environmental review was performed on the proposed TARP systems and subsystems based on the information presented by the MSDGC. The review did not indicate that any significant environmental impacts would result from the Addison-to-Wilmette segment of the Mainstream system. Consequently, a decision not to prepare an EIS was made for this segment. This action was taken on the basis of a careful review of the facilities plan, as well as of the environmental assessment report and of other supporting data. However, EPA review of the other tunnel system segments (Mainstream, Calumet, Lower Des Plaines, and O'Hare - Des Plaines did indicate the possibility of significant environmental impacts. The EPA then determined that the preparation of an environmental impact statement will be necessary for these tunnel segments.

1.8 SCOPE OF THE TARP EIS

The EIS for the MSDGC's Tunnel and Reservoir Plan addresses the environmental issues relevant to the conveyance tunnels and their component subsystems. These tunnels and associated subsystems are a part of the four TARP systems identified in the previous section. The purpose of the EIS is to assess the positive and negative impacts of TARP on the physical, biological, and socioeconomic environment; flood control systems are not included in the EIS. The Mainstream Tunnel system EIS includes only the Phase I tunnel and not the relief tunnel, which will be used for flood control purposes. Likewise, no proposed storage reservoirs are included, since their primary purpose is flood control.

The environmental impacts associated with each TARP system will be presented in a separate statement and will focus on the conveyance tunnels only. This EIS has been prepared for the Mainstream Tunnel System from 59th Street to Addison Street, in accordance with the regulations and guidance set forth in the President's Council on Environmental Quality (CEQ) Guidelines (August 1, 1973), and the

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[1] The U.S. Army Corps of Engineers is presently preparing an EIS for the flood control aspects of TARP.

U.S. EPA Final Regulations CFR 40-Part 6 (April 14, 1975). The guidelines and regulations concern the preparation of environmental impact statements.

For this proposed Tunnel and Reservoir Plan, the U.S. EPA, Region V, Chicago, Illinois, is the "responsible or lead Federal agency" as required by the National Environmental Policy Act of 1969 (NEPA).

To ensure that the public is kept fully informed regarding this action, and that it participates to the fullest extent possible in the Agency's decisionmaking process, this draft EIS is being circulated for a 45-day review as required by the CEQ, August 1, 1973, Guidelines. In addition, a public hearing is scheduled to be held in the near future.

II. EXISTING NATURAL ENVIRONMENT

II. EXISTING NATURAL ENVIRONMENT

This chapter describes the natural environment in the Chicago metropolitan area which may be affected by the proposed tunneling project. The information contained in this chapter provides a basis for evaluating the effects of the proposed project on the natural environment. Thus, only those elements of the natural environment that are likely to be affected by the proposed project are discussed. Instead of an exhaustive environmental inventory, only those details that are necessary for impact evaluation are presented.

This chapter is divided into the following three main sections:

- Water resources
- Land resources
- Atmospheric resources.

In the water resources section, the quantity and quality of surface water and groundwater that are likely to be affected by the mainstream tunnel systems are discussed. Sources polluting these waters are also identified. Finally, programs to abate pollution and to manage water resources in the entire Chicago metropolitan area are described.

The land resources section provides information on drainage basins served by the mainstream tunnel systems, and identifies the flood prone areas in the project service area. The geology and seismicity of the entire Chicago metropolitan area are described and pertinent details on the areas affected by the proposed project are given.

Finally, the air quality and noise levels in the Chicago metropolitan area are presented in the atmospheric resources section.

Each of these sections are discussed in detail below.

2.1 WATER RESOURCES

Chicago depends on the area's groundwater and surface water supplies for many uses beyond drinking water, including commerce, transportation, recreation, and sanitation. This section describes the status of Chicago area water resources prior to the implementation of TARP. The discussion of groundwater and surface water supply addresses the following topics:

- Quality, availability, and uses of water resources
- Pollution sources
- Resource management programs
- Flood prone areas.

2.1.1 Surface Water

The surface waterways of the Chicago area constitute an interconnected network of rivers and canals whose natural flow into Lake Michigan has been reversed by a series of locks. The major surface waterways under study are the Chicago River - Sanitary and Ship Canal System, the Calumet River System, the Des Plaines River System, Lake Calumet, and Lake Michigan. The remainder of this section describes the quality and availability of surface water supplies, the regulation of surface water flow, the potable water supplies, and the deposition of sludge in the three water systems. These systems are depicted in Figure II-1.

The Chicago River System includes:

- North Shore Channel from Lake Michigan at Wilmette

- North Branch of the Chicago River from the confluence of West Fork and the Skokie River downstream to the Chicago River

- Chicago River flowing westward from the Chicago River Controlling Works at Lake Michigan to the junction with the North and the South Branches of the Chicago River

- Tributaries to the North Branch of the Chicago River as they cross the Lake-Cook County line.

The Chicago Sanitary and Ship Canal System includes the South Branch of the Chicago River from the junction with the North Branch, the Chicago River, and the Sanitary and Ship Canal downstream to the Lockport Lock and Dam.

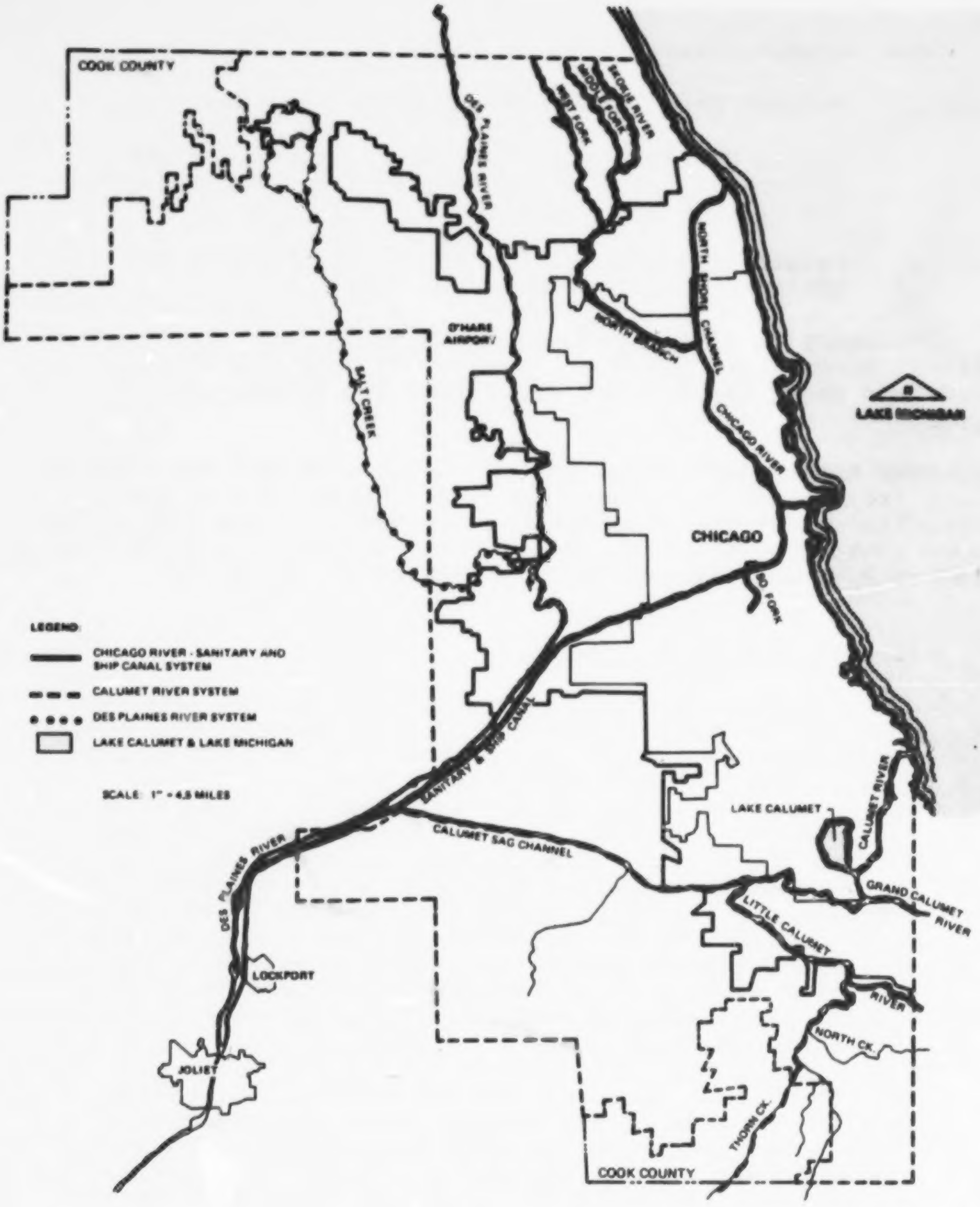
COOK COUNTY
DES PLAINES RIVER
WEST FORK
MIDDLE FORK
SKOKIE RIVER
NORTH SHORE CHANNEL
NORTH BRANCH
O'HARE AIRPORT
SALT CREEK
CHICAGO RIVER
LAKE MICHIGAN
CHICAGO
SO. FORK
SANITARY & SHIP CANAL
LAKE CALUMET
CALUMET RIVER
CALUMET SAG CHANNEL
GRAND CALUMET RIVER
LITTLE CALUMET RIVER
NORTH CK.
THORN CK.
DES PLAINES RIVER
LOCKPORT
JOLIET
COOK COUNTY
LEGEND:
CHICAGO RIVER - SANITARY AND SHIP CANAL SYSTEM
CALUMET RIVER SYSTEM
DES PLAINES RIVER SYSTEM
LAKE CALUMET & LAKE MICHIGAN
SCALE: 1" = 4.5 MILES

FIGURE II-1
Chicago Area Waterways

The Calumet River System includes:

- Calumet River from Lake Michigan westward
- Little Calumet River from where it crosses the Indiana-Illinois State line to its junction with the Calumet-Sag Channel
- Calumet-Sag Channel to its confluence with the Sanitary and Ship Canal.

Tributaries to the Calumet River System are the Grand Calumet River which joins the system south of the O'Brien Locks and Thorn Creek which flows into the Little Calumet River.

The Des Plaines River System consists of the Des Plaines River from where it crosses Lake-Cook County line to just above its confluence with the Chicago Sanitary and Ship Canal above Lockport, Illinois. Salt Creek, a tributary to the Des Plaines River, joins the river at Riverside, Illinois.

(1) Surface Water Quality

The quality of Chicago area waterways is affected not only by steady-state effluent discharges, but also by periodic injections of pollutants as well. These pollutants are due to combined sewer overflows during storm events. Approximately 100 times per year rainfall runoff causes the combined sewer loads to overflow to area streams and rivers. The frequency and severity of these overflow episodes is sufficient to negate any improvements in water quality due to control of other point sources. The problem of combined sewer overflows will be discussed in more detail in Section 2.1.3 on pollution sources. In this section water quality data will be presented and related to allowable water uses in the Chicago area.

The MSDGC routinely carries out a water quality sampling program of the Chicago River - Sanitary and Ship Canal System, the Calumet River System, the Des Plaines River System, and their tributaries. Samples are taken by the MSDGC at least once each month at 41 stations which are shown in Figure II-2. Some stations are sampled twice each month. The samples are analyzed for various physical, chemical, and biological characteristics. The physical analysis includes

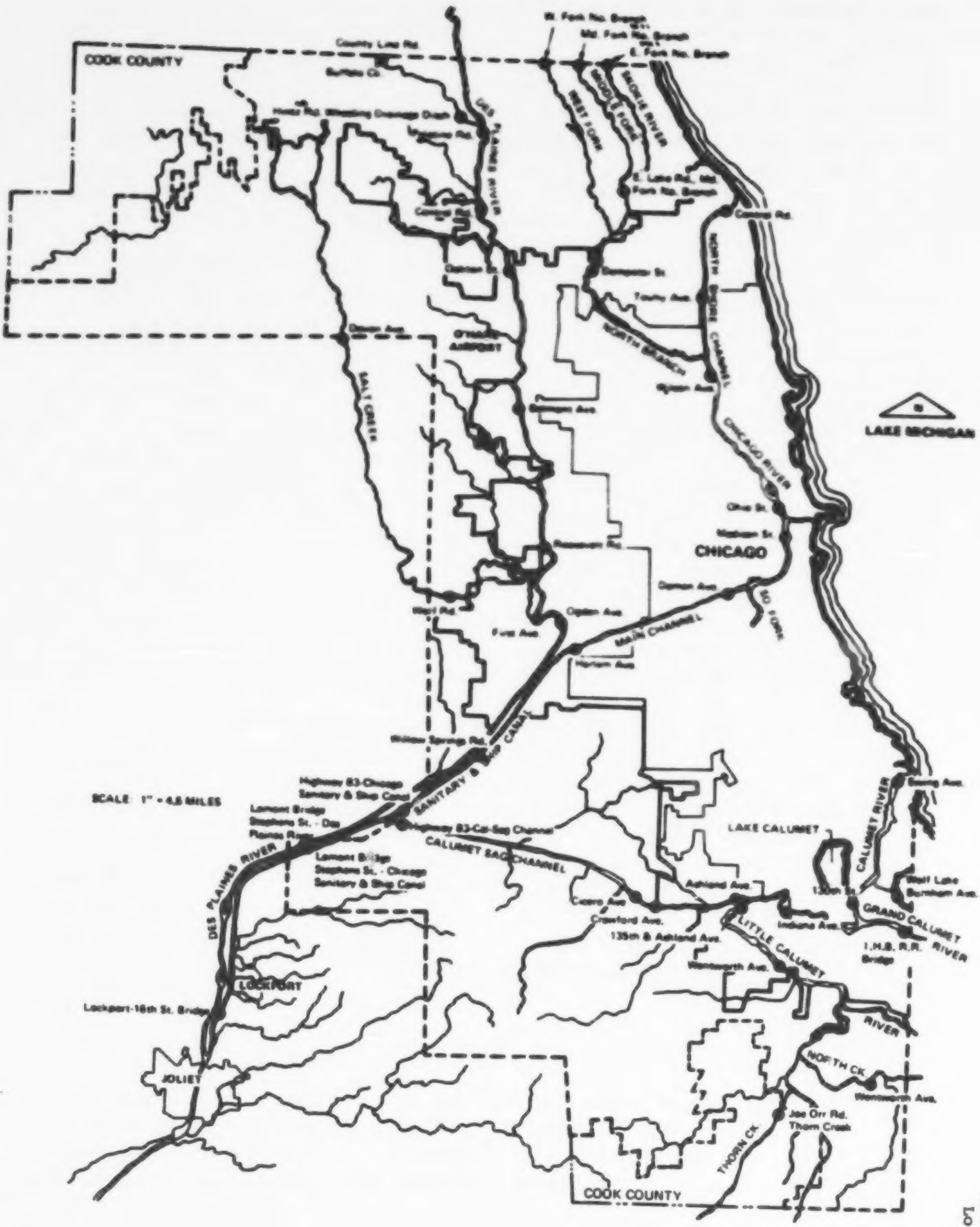
COOK COUNTY
County Line Rd.
Buffalo Cr.
W. Fork No. Branch
Md. Fork No. Branch
E. Fork No. Branch
Wheeling Drainage Ditch
DES PLAINES RIVER
WEST FORK
MIDDLE FORK
SKOKIE RIVER
Lake Rd.
Fork No. Branch
Central Rd.
Dempster St.
Touhy Ave.
NORTH SHORE CHANNEL
NORTH BRANCH
O'HARE AIRPORT
SALT CREEK
CHICAGO RIVER
LAKE MICHIGAN
Ohio St.
Madison St.
CHICAGO
Roosevelt Rd.
Ogden Ave.
Wolf Rd.
Fuel Ave.
MAIN CHANNEL
SO. FORK
Harlem Ave.
Willow Springs Rd.
SANITARY & SHIP CANAL
SCALE: 1" = 4.5 MILES
Highway 83-Chicago Sanitary & Ship Canal
Lemont Bridge Stephens St. - Des Plaines River
Highway 83-Cal-Sag Channel
CALUMET SAG CHANNEL
Lemont Bridge Stephens St. - Chicago Sanitary & Ship Canal
DES PLAINES RIVER
LOCKPORT
Lockport-16th St. Bridge
JOLIET
Cicero Ave.
Crawford Ave.
135th & Ashland Ave.
Ashland Ave.
Wentworth Ave.
LAKE CALUMET
CALUMET RIVER
Ewing Ave.
130th St.
Wolf Lake Burnham Ave.
Indiana Ave.
GRAND CALUMET RIVER
I.H.B. R.R. Bridge
LITTLE CALUMET RIVER
NORTH CK.
Wentworth Ave.
Joe Orr Rd. Thorn Creek
THORN CK.
COOK COUNTY

FIGURE II-2
Waterway Sampling
Location Points

determination of temperature and concentration of suspended and dissolved solids. Chemical factors analyzed include: dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), ammonia-nitrogen, nitrite-nitrate nitrogen, total phosphorus, methylene blue-active substances (MBAS), cyanide (CN), and the heavy metals. Bacteriological tests are performed to determine total and fecal coliform concentrations and the presence of fecal strep.

A summary of the data collected and analyzed by the MSDGC is presented in the sections below for the three major waterway systems. The presentations of average pollutant concentrations for the three systems follow closely the discussion of the MSDGC's monitoring program for water quality found in Appendix C of "Facilities Planning Study - MSDGC Overview Report," second revision, January 1975. Of the many parameters routinely monitored by MSDGC, five key water quality indicators are discussed in the sections below: dissolved oxygen (DO), biological oxygen demand (BOD), ammonia nitrogen, suspended solids (SS), and fecal coliform counts. The measured levels of each parameter are summarized in tabular form and related to applicable standards for each of the three major waterways at the close of the discussion of water quality in Table II-2.

Reference is made in the discussion to Table II-1 showing Illinois water quality standards. Virtually all of Chicago's major surface water bodies, except for Lake Michigan, are classified under water standards for Secondary Contact and Indigenous Aquatic Life. This is the lowest water use designation made by the State of Illinois, allowing only uses in which "contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal".[1]

1. Chicago River - Sanitary and Ship Canal

Average water quality parameters for the Chicago-River-Sanitary and Ship Canal System for 1973 are presented in Table A-1 of Appendix A. Some of the general findings are discussed below.

---

[1] Illinois Pollution Control Board Rules and Regulations, Chapter 3, Water Pollution.

Table II-1
Selected Illinois Standards for Water Use and Effluent Discharge[1]

Parameter	General Use Standards[a]	Public and Food Processing Water Supply Standards[b]	Secondary Contact and Indigenous Aquatic Life Water Standards[c]	Lake Michigan Standards	Effluent Discharge Standards
Unnatural Sludge Deposits	None Allowed	None Allowed	None Allowed	None Allowed	None Allowed
Floating Debris	None Allowed	None Allowed	None Allowed	None Allowed	None Allowed
Oil	No Visible Oil Allowed	0.1 mg/l	15 mg/l	0.1 mg/l	15 mg/l
Unnatural Plant Growth	None Allowed	None Allowed	None Allowed	None Allowed	None Allowed
Unnatural Color or Turbidity	None Allowed	None Allowed	None Allowed	None Allowed	None Allowed
Odor	None Allowed	None Allowed	None Allowed	None Allowed	None Allowed
pH	6.5-9.0	6.5-9.0	6.0-9.0	7.0-9.0	5.0-10.0
Dissolved Oxygen (DO)	5.0 mg/l minimum	6.0 mg/l minimum	2.0 mg/l min.; 4.0 mg/l after 12/31/77	> 90% of saturation value	10 mg/l BOD_5; 12 mg/l, SS[d].
Phosphorus	0.05 mg/l	0.05 mg/l	1.0 mg/l max.	0.007 mg/l	1.0 mg/l max.
Cadmium	0.05 mg/l	0.01 mg/l	0.15 mg/l	0.01 mg/l	0.15 mg/l
Total Dissolved Solids (TDS)	1000 mg/l	500 mg/l	3500 mg/l max.	180.0 mg/l	<750 mg/l above background
Ammonia-nitrogen	1.5 mg/l	1.5 mg/l	4.0 mg/l max.	0.02 mg/l	4.0 mg/l max.
Temperature	5°F max. above natural level	5°F max. above natural level	<93°F for 98% of time; 100°F max.	3° max. above natural level	<20°F above ambient
Fecal Coliforms	200/100 ml, 30-day geometric mean	200/100 ml, 30-day geometric mean	1,000/100 ml, 30-day geometric mean	20/100 ml, 30-day geometric mean	400/100 ml

a. General Use Waters: All Illinois waters except those designated as Secondary Contact and Indigenous Aquatic Life Waters.
b. Public and Food Processing Water Supply: All Illinois waters except those designated as Secondary Contact and Indigenous Aquatic Life Waters and except for the Chicago River and Little Calumet River.
c. Secondary Contact and Indigenous Aquatic Life Waters: 1) Sanitary and Ship Canal, 2) Calumet—Sag Channel, 3) Little Calumet River from junction with Grand Calumet River to Calumet—Sag Channel, 4) Grand Calumet River, 5) Calumet River, 6) Lake Calumet, 7) South Branch of the Chicago River, 8) North Branch of Chicago River from confluence with North Shore Channel to confluence with South Branch, 9) Des Plaines River from confluence with Chicago Sanitary and Ship Canal to the Interstate 55 Bridge, 10) North Shore Channel except that DO standard for Channel shall be 5 mg/l for 16 hours out of 24 hour period and not less than 4 mg/l at any time.
d. BOD and Suspended Solids standard for sources with dilution ratio less than 5 to 1.

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[1] Illinois Pollution Control Board Rules and Regulations, Chapter III, Water Pollution.

The average dissolved oxygen concentration decreased with increasing distance from Lake Michigan, ranging from 7.65 mg/l at the upstream stations on the North Shore Channel to 3.4 mg/l at Ohio Street on the North Branch of the Chicago River. The Sanitary and Ship Canal showed dissolved oxygen levels that varied from 5.53 mg/l just after the confluence of the Chicago River down to 1.2 mg/l at the downstream stations.

The average BOD of the water entering the North Shore Channel was about 5.2 mg/l. This increased to 9.2 mg/l in the downstream sector of the North Branch of the Chicago River while the observed levels of BOD in the Sanitary and Ship Canal ranged between 5.5 and 7.4 mg/l.

Ammonia levels increased as incoming Lake Michigan waters mixed with effluents discharged from area treatment plants and other sources. Ammonia-nitrogen averaged 0.84 mg/l-N near the lake and increased downstream to 5.49 mg/l-N. After mixing with Chicago River water the average ammonia concentration decreased to 3.49 mg/l, but then increased to 6.22 mg/l below the West-Southwest Sanitary Treatment Works discharge.

The average suspended solids concentration decreased from 54 mg/l to a level of about 22 mg/l in the lower reach of the North Branch of the Chicago River. Levels at the stations along the Sanitary and Ship Canal varied between 19 and 31 mg/l.

Fecal coliform counts ranged from a geometric mean of 3,134 per 100 ml at Central Avenue to 12,705 per 100 ml at Ohio Street on the North Branch of the Chicago River. However, immediately below the North Side Sanitary Treatment Works the geometric mean dropped to 477 per 100 ml. The highest counts in the Sanitary and Ship Canal System were at Damen Avenue with a geometric mean of 5,512 per 100 ml. These levels dropped below the West-Southwest Sanitary Treatment Works to a geometric mean of 770 per 100 ml.

The significance of these measurements becomes apparent from an examination of Table II-1, Illinois Water Quality Standards. Water standards for

Secondary Contact and Indigenous Aquatic Life are not met for dissolved oxygen, ammonia-nitrogen and fecal coliforms along large segments of the Chicago River - Sanitary and Ship Canal System. Standards for biological oxygen demand (BOD) and suspended solids (SS) have been set only for effluents discharged to streams. BOD values in the open waterways are close to the discharge standard, and SS concentrations exceed the discharge standard in many areas. This situation emphasizes the need for continued upgrading of existing pollution sources to comply with effluent discharge regulations.

2. Calumet River System

Table A-2 of Appendix A shows the average values of various water quality parameters for 1973 from sampling stations along the Calumet River System. A discussion of some of the important parameters follows.

Dissolved oxygen levels in the Calumet River System averaged 9.0 mg/l at the mouth of the river and gradually declined downstream until at Highway 83 on the Cal-Sag Channel. The average concentration was 3.9 mg/l.

The BOD of the Calumet River stations averaged 4.1 mg/l, increasing to 7.3 mg/l below the Calumet Sanitary Treatment Works and the confluence of the Little Calumet River. The BOD level then declined slowly to 6.2 mg/l in the Calumet-Sag Channel just above the confluence with the Sanitary and Ship Canal.

Within the main waterways of the Calumet River System the ammonia concentrations ranged from 1.31 mg/l-N at 92nd Street to 9.1 mg/l-N at Ashland Avenue below the Calumet Sanitary Treatment Works. The highest ammonia levels occur in the Grand Calumet River with an average of 13.3 mg/l-N.

The average concentration of suspended solids at the various sampling stations of the main waterways fell between 12 mg/l and 73 mg/l. The highest concentrations occurred in the tributary streams.

Fecal coliform counts were lowest near the mouth of the Calumet River with a geometric mean of 152 per 100 ml. The highest counts were observed in the lower part of the Cal-Sag Channel with a geometric mean of 738 per 100 ml. Extremely high fecal coliform counts were obtained in the two tributaries just below the Indiana-Illinois line averaging 18,200 and 24,500 counts per 100 ml on the Grand Calumet and Little Calumet River, respectively.

In summary, dissolved oxygen concentrations along the Calumet River System currently exceed the water standards for Secondary Contact and Indigenous Aquatic Life. Measured values of ammonia-nitrogen and fecal coliforms did not meet minimum standards over large portions of the system and measured values for suspended solids in the stream did not meet the effluent discharge standard.

3. Des Plaines River System

Average 1973 values for various water quality parameters are given in Table A-3 of Appendix A. A brief discussion of some important factors follows.

The average dissolved oxygen levels found in the Des Plaines River ranged from 6.0 mg/l to 10.2 mg/l. Some values greater than saturation occurred probably as a result of photosynthetic oxygen production.[1]

BOD levels at the Lake-Cook County line averaged 6.7 mg/l. This level decreased slightly moving downstream to an average of 5.0 mg/l. Some of the highest levels were observed in Salt Creek, with an average of 6.1 mg/l, just above the junction with the Des Plaines River.

The Des Plaines River had relatively low levels of ammonia with average concentrations between 0.34 mg/l-N and 1.21 mg/l-N. Salt Creek had the highest ammonia levels averaging 2.92 mg/l-N at one location.

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[1] MSDGC, "Facilities Planning Study - MSDGC Overview Report," Appendix C, "Water Sampling, Testing and Water Quality Monitoring Program," Revised January 1975.

The concentration of suspended solids fluctuated from a high of 68 mg/l at the Lake-Cook County line down to a low of 29 mg/l at Ogden Avenue in the lower reach of the river.

Fecal coliform counts on the Des Plaines River fluctuated from a low geometric mean of 411 counts per 100 ml at the county line to a high of 8,699 counts per 100 ml in the middle reach and then declined to 1,692 counts per 100 ml at Willow Springs Road.

In comparison with the General Use Standards applicable to that portion of the Des Plaines sampled by the MSDGC, the data presented in Table II-2 shows that concentrations of dissolved oxygen and ammonia-nitrogen are better than those levels mandated by the standard; however, fecal coliform counts exceed allowable levels along portions of the Des Plaines River. In addition, suspended solids concentrations in the river are higher than those allowed under effluent discharge standards.

4. Water Quality Standards

As indicated in Table II-1, Illinois has developed four classifications of water use: general use, public and food processing water supply, restricted use, and Lake Michigan. General use waters should be suitable for supporting aquatic life; all waters except those designated as restricted are for general use. Water standards for public and food processing are somewhat more stringent than those for general use. As noted in Table II-1, all Illinois waters should be suitable for public and food processing water supply except for restricted waters and the Chicago and Little Calumet Rivers. Standards for Lake Michigan are even more stringent than those covering public and food processing water supply.

Those waters classified as restricted (Secondary Contact and Indigenous Aquatic Life water use) are allowed to meet less stringent water quality standards. All Illinois waterways on the restricted list belong to one of the three major waterways under discussion here. The presentation of water quality data made earlier showed

Table II-2
Summary of Pollutant Concentration
Ranges in Chicago's Surface Water Systems

Pollutant	Chicago River — Sanitary and Ship Canal System	Calumet River System	Des Plaines River System	Applicable Illinois Standard
Dissolved oxygen (DO)	1.2 to 7.7 mg/l	3.9 to 9.0 mg/l	6.0 to 10 mg/l	4.0 mg/l (1977)[1] 5.0 mg/l min.[2]
Biochemical oxygen demand (BOD)	5.2 to 9.2 mg/l	4.1 to 7.3 mg/l	5.0 to 6.7 mg/l	10 mg/l[3]
Ammonia (as N)	0.8 to 6.2 mg/l	1.3 to 13 mg/l	0.3 to 1.2 mg/l	4.0 mg/l[1] 1.5 mg/l[2]
Suspended solids (SS)	19 to 54 mg/l	12 to 73 mg/l	29 to 68 mg/l	12 mg/l[3]
Fecal coliform	477 to 12,700 (counts/100 ml)	152 to 738 (counts/100 ml)	411 to 8,700 (counts/100 ml)	1000/100 ml[1] 200/100 ml[2]

[1] Secondary Contact and Indigenous Aquatic Life Standards applicable to Chicago River-Sanitary and Ship Canal system and Calumet River system.

[2] General Use Standard applicable to Des Plaines River systems.

[3] Effluent Discharge Standard.

that standards for restricted use are not met along sizable segments of all three river systems. This data is summarized and compared to Illinois Standards in Table II-2. For these areas even secondary contact would be ruled out. Eventual use of the substandard segments would depend largely upon improvements in dissolved oxygen, ammonia-nitrogen, and fecal coliform values.

Some Federal guidelines in this area are available in the form of suggested minimum standards for various water uses (see Table II-3). Although these suggested standards do not provide a comprehensive basis for deciding appropriate water uses in the Chicago area, these Federal guidelines do indicate that, if Illinois standards for water use were met, water quality would be suitable on currently substandard segments for designated recreational uses. In addition, if applicable Illinois water quality regulations were met, primary contact would be possible on the river sections not classified as restricted (North Branch of the Chicago River, Des Plaines River upstream from McCook, part of the Little Calumet River, Des Plaines-Illinois River, and Lake Michigan). In other areas at least secondary contact (boating but not swimming or game fishing) would be allowed. These potential water uses, assuming Illinois water quality standards are met, are shown in Figure II-3.

(2) Surface Water Quantity

Data on the flows and elevation levels of the major surface waterways in the Chicago area are presented below. These surface waterways include the Chicago River - Sanitary and Ship Canal, Des Plaines River, Calumet River, Lake Calumet, and Lake Michigan. For the river systems, the existing low, mean, and high flow rates (annual average) are provided for specific locations. For the river systems and lakes, the low, mean, and high surface evaluation levels (annual average) are given based on U.S. Geological Survey Datum. (Elevetion 579.48 USGS corresponds to Elevation 0.00 Chicago City Datum.)

1. Chicago River - Sanitary and Ship Canal

Annual average flow rates (low, mean, and maximum) for gaging stations along the North

Table II-3[1]
Minimum Federal Standards for Selected Water Uses[a]

	General Recreational[b]	Designated Recreational[c]	Primary Contact[d]	Growth of Freshwater Organisms
Fecal Coliform				
Mean	2,000/100 ml	1,000/100 ml	200/100 ml	-
Minimum	4,000/100 ml	2,000/100 ml	400/100 ml	-
pH				
Normal Range			6.5-8.3	-
Absolute Range			5.0-9.0	6.0-9.0
Dissolved Oxygen				
Coldwater Biota				
Mean				7.0 mg/l
Spawning Mean				6.0 mg/l
Normal Mean				4.0 mg/l
Warm Water Biota				
Mean				5.0 mg/l
Minimum				4.0 mg/l
Total Dissolved Solids				
Minimum			1,500 mg/l	

[a] These are suggested standards.

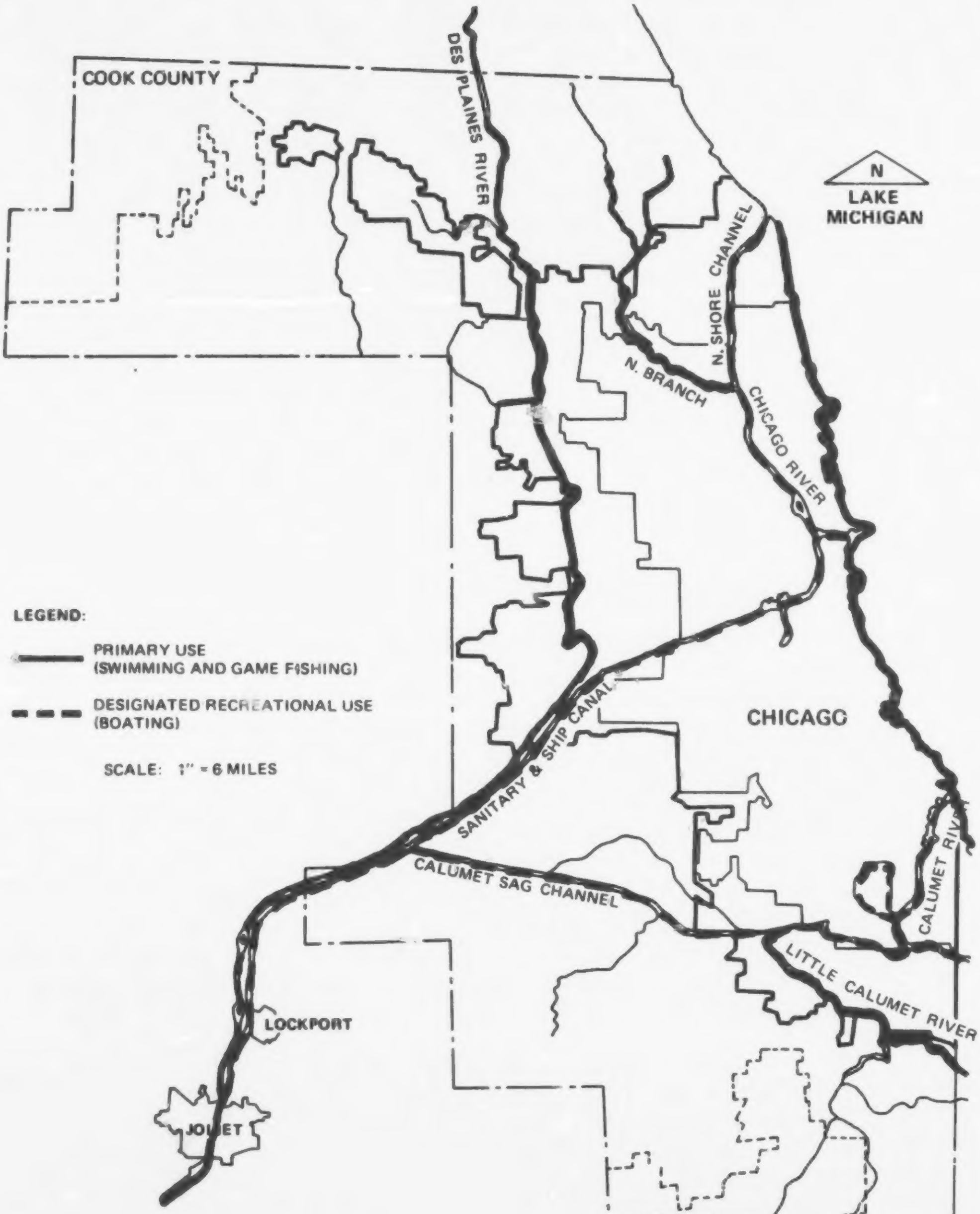
[b] General recreational use areas are those areas suitable for human use in recreation activities not involving significant risks of ingestion without reference to official designation of recreation as a water use.

[c] Designated recreational use areas are those areas suitable for recreational activities not involving significant risks of ingestion and officially designated as a recreation area.

[d] Primary contact use areas are those areas suitable for human use in recreation activities involving significant risks of ingestion.

[1] Federal Water Pollution Control Administration, U.S. Department of Interior, Water Quality Criteria: Report of the National Technical Advisory Committee, April 1, 1968, Washington, D.C. (U.S. EPA expects to publish later this year a set of guidelines to replace this report.)

FIGURE II-3
Recreational Uses of Chicago
Waterways Assuming Illinois
Standards Are Met


DES PLAINES RIVER
COOK COUNTY
N
LAKE
MICHIGAN
N. SHORE CHANNEL
N. BRANCH
CHICAGO RIVER
LEGEND:
PRIMARY USE
(SWIMMING AND GAME FISHING)
DESIGNATED RECREATIONAL USE
(BOATING)
SCALE: 1" = 6 MILES
SANITARY & SHIP CANAL
CHICAGO
CALUMET RIVER
CALUMET SAG CHANNEL
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY

Branch of the Chicago River for the years 1960 to 1969 are shown in Table II-4. Also shown in Table II-4 are the stream stages corresponding to the annual maximum flow rate. As the table shows, the lowest mean stream flow for the North Branch, 2.48 cubic feet per second (CFS), occurred in 1963 while the highest values for mean flow, 118 CFS and 112 CFS, were recorded in 1965 and 1969, respectively. Over this 10-year period, the largest fluctuation in stream elevation at maximum flow, was almost four feet. It was recorded at the gaging station farthest downstream and measured from 611.82 feet to 608.08 feet above Mean Sea Level (MSL). Table II-4 also contains flow data for the same period recorded farther downstream at the Lockport Lock on the Sanitary and Ship Canal. At this point, lowest values for mean flow, 3359 CFS and 3342 CFS, were observed in 1963 and 1964 while the highest value for mean flow, 3473 CFS, was recorded in 1962. The water depth and flow rate in the Sanitary and Ship Canal is maintained at a nearly constant level by additions from Lake Michigan to allow navigation.

2. Calumet River System

The Calumet River, from 1971 through October 1975 had an average flow rate of 335 CFS with high and low flow values of 4,378 CFS and 238 CFS, respectively, as measured just downstream of O'Brien Lock and Dam. The river level at this point fluctuated six feet over that four-year period, or between 582.98 and 576.98 feet with a mean elevation of 577.58 feet above MSL.

Little Calumet River over the same period had a mean flow rate of 324 CFS with high and low flow extremes of 3,176 CFS and 38 CFS, respectively. Surface water levels ranged from 582.98 and 576.98 feet with a mean level of 577.38 feet above MSL.

In the Calumet-Sag Channel over the period from 1966 to 1975 estimates of flow rates past the Cal-Sag Junction ranged from a low of 293 CFS to a high of 10,000 CFS with a mean value of 1,078 CFS. Levels in the Cal-Sag Channel varied 5.4 feet from 580.88 to 575.48 feet with a mean elevation of 577.18 feet above MSL.

Table II-4

Annual Average Flow Rates[1] and Maximum Stream Stages[2] Along the Chicago River - Sanitary and Ship Canal, 1960-1969

Year	North Branch, Chicago River at Deerfield				West Fork - North Branch, Chicago River at Northbrook				North Branch, Chicago River at Niles				Sanitary and Ship Canal at Lockport			
	Flow Rate (CFS)			Elevation	Flow Rate (CFS)			Elevation	Flow Rate (CFS)			Elevation	Flow Rate (CFS)			Elevation
	Min.	Mean	Max.	(Max.Ft.)	Min.	Mean	Max.	(Max.Ft.)	Min.	Mean	Max.	(Max.Ft.)	Min.	Mean	Max.	(Max.Ft.)
1960	0	15.6	284	648.47	0.7	11.5	275	645.99	7.7	92.3	1340	610.14	494	3427	16834	
1961	0	10.3	178	647.68	0	11.0	502	644.85	6.0	73.5	1290	610.11	462	3411	19423	
1962	0	11.8	268	647.74	0	9.09	428	644.54	2.4	63.1	1010	609.37	181	3473	16860	
1963	0	2.48	134	646.98	0.10	4.15	350	644.19	4.0	29.7	905	609.13	157	3359	22801	
1964	0	8.02	228	647.34	0.20	9.49	298	644.67	5.6	57.3	810	608.81	164	3342	16286	
1965	0.10	23.3	208	647.46	0.20	15.5	285	643.84	10.0	118	658	608.08	508	3413	19268	
1966	0	13.0	311	647.96	1.20	10.8	390	644.98	6.8	91.9	1360	610.24	530	3363	25508	
1967	0	14.3	386	648.34	0.80	13.4	712	646.84	6.9	93.7	2210	611.82	168	3439	18154	
1968	0.26	8.69	173	647.25	3.20	9.91	397	644.33	8.9	63.0	858	608.95	461	3422	28598	
1969	0.39	21.4	359	648.26	3.10	17.2	634	645.58	14.0	112	1300	610.86	197	3400	19738	

[1] USGS, *Surface Water Supply of the United States*, "Water Supply Papers Corresponding to Upper Mississippi River Basin Below Keokuk, Iowa," [illegible].

[2] for stream stage data: U.S. Department of Commerce, *Hydrograph of Monthly Mean Levels of the Great Lakes*, 1971.

3. Des Plaines River System

Data for 1970 on flow and water elevation were reported by the Illinois Division of Waterways for two gaging stations along the Des Plaines River and for one station on Salt Creek. At Hoffman Dam on the Des Plaines River the mean yearly flow rate was found to be 890 CFS, with average high and low flow rates of 3,800 CFS and 366 CFS, respectively. Water elevation varied from 606.88 feet at low flow to 612.78 feet at flood level with a mean elevation of 609.48 feet above MSL.

Further upstream at the Des Plaines Gage stream flow averaged 503 CFS with average high and low flow rates of 2,000 CFS and 215 CFS, respectively. Water elevations measured at this point fluctuated about a mean of 627.28 feet above MSL with high and low elevations of 629.88 feet and 626.78 feet recorded, respectively.

The Western Springs Gage on Salt Creek registered high and low flow rates of 1,050 CFS and 85 CFS, respectively, with a calculated mean flow rate of 137 CFS. Stream elevation fell to between 631.88 feet and 625.68 feet above MSL with a mean elevation of 626.98 feet.

4. Lake Calumet and Lake Michigan

The surface elevations of these two lakes, as observed from 1900 through 1974, have varied together from 585.08 feet to 576.68 feet above MSL with a common mean elevation of 579.38 feet.

(3) Flow Regulation

Serious public health problems involving contamination of the city's drinking water supply led Chicago to implement measures to protect Lake Michigan, an important source of drinking water, from pollution. The approach adopted was to alter the drainage pattern of the area through the construction of a system of canals, locks, and sluice gates. Under this program the natural flow of several waterways into Lake Michigan was diverted and in some cases reversed so that rainfall runoff drained away from Lake Michigan and into the Illinois

River. This program led to the creation of the Chicago River - Sanitary and Ship Canal System and to the modification of the Calumet River System as described below.

1. Control Measures

The Sanitary and Ship Canal was completed in 1900 followed by the completion of the North Shore Channel in 1910. The construction of this system allowed surface water flow from the North Branch of the Chicago River, the North Shore Channel, the Chicago River and the South Branch of the Chicago River to be discharged to the Illinois River rather than to Lake Michigan, the original receiving body. Water levels in the Chicago River are now controlled by a system of sluice gates. Navigation is made possible by a boat lock at Wilmette.

Similarly, the completion of the Calumet-Sag Channel in 1922 allowed the MSDGC to either fully or partially reverse the flow of the Little Calumet, the Grand Calumet, and the Calumet Rivers away from Lake Michigan. These rivers now flow, by means of the Calumet-Sag Channel, into the Sanitary and Ship Canal at Sag Junction. Water levels in the Calumet River System are regulated by the Thomas J. O'Brien Controlling Works and Locks on the Calumet River.

2. Stormwater Runoff

The lock system is designed to prevent the flow of polluted water into Lake Michigan. Prior to a storm the water level in the Sanitary and Ship Canal is lowered at Lockport to accommodate expected runoff volumes. Storms generating in excess of 0.1 inch of runoff exceed the capacity of the interceptor sewers and cause an overflow of rainwater and raw sewage into local waterways at about 640 locations. This currently happens approximately 100 times per year.[1] Under severe circumstances rainfall runoff surpasses even the storage capacity of the river systems, threatening widespread flooding of the combined sewer area. Water levels at the controlling locks, located at Wilmette on the North Shore Channel, at the mouth of the Chicago River, and at O'Brien Lock on the Calumet River, are allowed to rise to heights of five feet, three feet, and three feet, respectively, above Chicago City Datum (approximately the level of Lake Michigan). Above this point, impounded waters are released to Lake Michigan to prevent severe flooding. Over the last 21 years there have been 30 occasions on which the locks were opened to Lake Michigan, releasing biological oxygen demand (BOD), sediment, phosphorus, and other pollutants.

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[1] "Facilities Planning Study - MSDGC Overview Report," Revised January 1975.

Releases made during the summer cause the closing of public beaches until coliform counts are reduced to safe levels. Other impacts include flooding of basements and ground floors of homes and businesses as well as flooding of major transportation arteries. Navigation along waterways is disrupted during the drawing down of waterway levels in anticipation of a storm and does not return to normal until channel levels and velocities have subsided.

(4) Domestic Water Supply

Lake Michigan has traditionally supplied most of the drinking water for the Chicago area. Withdrawal of water from the lake was essentially unlimited until 1930 when the U.S. Supreme Court set a ceiling of 1,500 CFS including domestic pumpage. The amount was revised upward in 1970 to 3,200 CFS including domestic pumpage. This amount of water taken from Lake Michigan over a period of one year, 2,317,000 acre-feet in all, supplies most domestic needs and supplements flow in area waterways, allowing for improved effluent dilution and improved navigation.

The 3,200 CFS allotment is divided among three uses: domestic needs, indirect diversion, and direct diversion. In 1970 domestic use constituted about 50 percent or 1,600 CFS of the total of 3,200 CFS. This amount supplied the water needs of 4,520,000 people within the city of Chicago service area.

Indirect diversion is that estimated quantity of stormwater runoff which formerly drained directly into Lake Michigan but which now is diverted to other area waterways. This amount varies depending upon yearly rainfall.

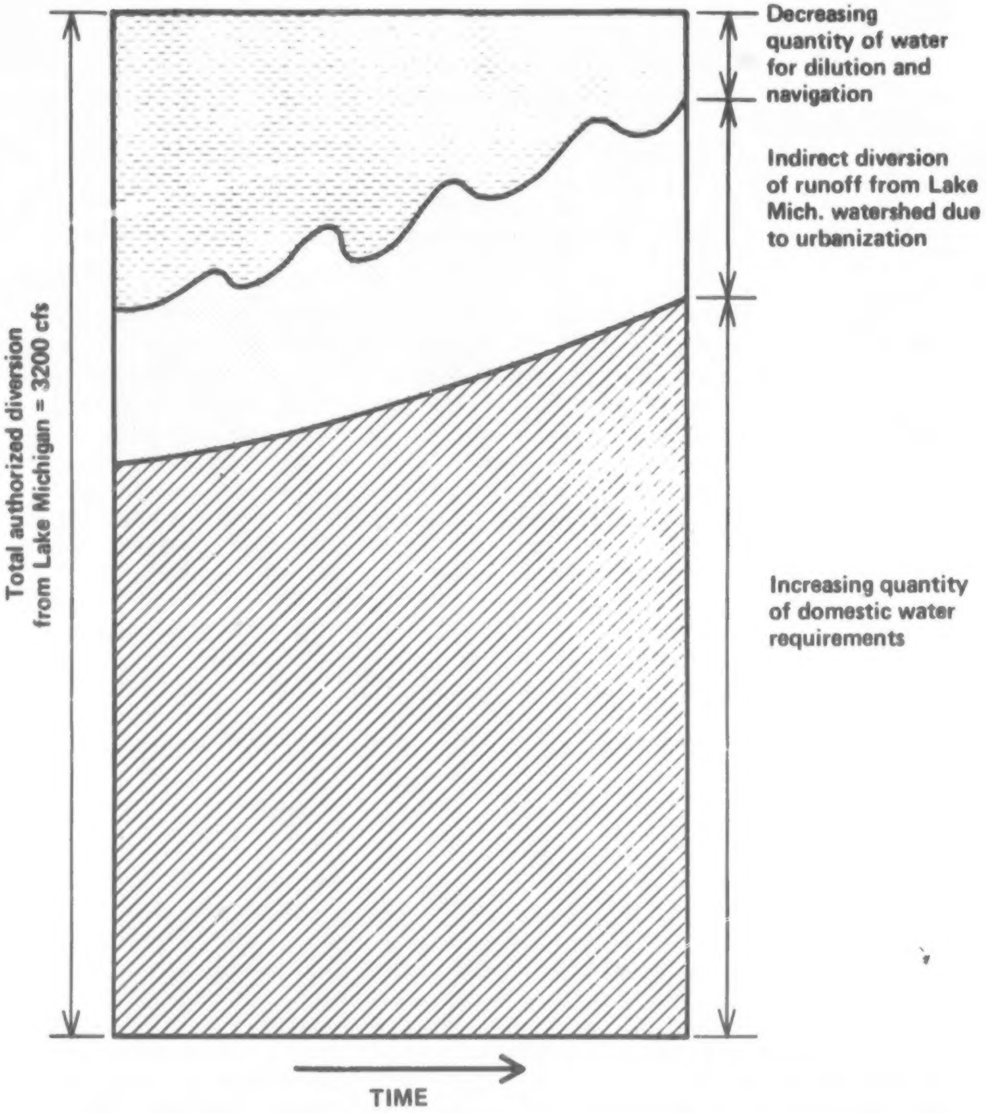
When the water supplied for domestic use and the water diverted from Lake Michigan (indirect diversion) are subtracted from the 3,200 CFS allotment, the amount remaining is available for direct diversion use, i.e., diversion to local waterways for effluent dilution and for navigation. The relationship among these three components of Lake Michigan pumpage is portrayed in Figure II-4.

It is clear from the discussion that as domestic water needs increase, less water will be available for direct diversion uses. This assumes that the 3,200 CFS ceiling is to be maintained and that indirect diversion remains relatively constant. Present water supplies are adequate for current needs but increases in population and in commercial and industrial water users are likely to lead to increased demands for water. Although some of this demand may be met by increased groundwater utilization, groundwater pumpage in some portions of the Chicago area already exceeds recharge. By storing combined sewer overflow until it can be treated and released to area waterways, the proposed tunnel systems with their total storage capacity of 9,100 acre-feet will help to alleviate dilution and navigation problems to an extent dependent on the frequency and severity of storms.

(5) Benthal Deposits

Raw sewage sludge and sediment washed into surface waterways during overflow episodes add to the pollution load. Organic material deposited in this manner degrades water quality by consuming oxygen during its stabilization and by liberating BOD to overlying waters. During stabilization of the organic wastes anaerobic as well as aerobic conditions prevail as the depth of the deposits increases. Figure II-5 illustrates the accumulation of benthal (bottom) deposits in the Chicago Sanitary and Ship Canal from below the Lockport Lock to just above Damen Avenue. Canal deposits lying between Willow Springs Road and Damen Avenue range from about five to 13 feet in depth. Waterway deposits

FIGURE II-4
Components of Lake Michigan Diversion[1]


Decreasing quantity of water for dilution and navigation
Indirect diversion of runoff from Lake Mich. watershed due to urbanization
Increasing quantity of domestic water requirements
Total authorized diversion from Lake Michigan = 3200 cfs
TIME

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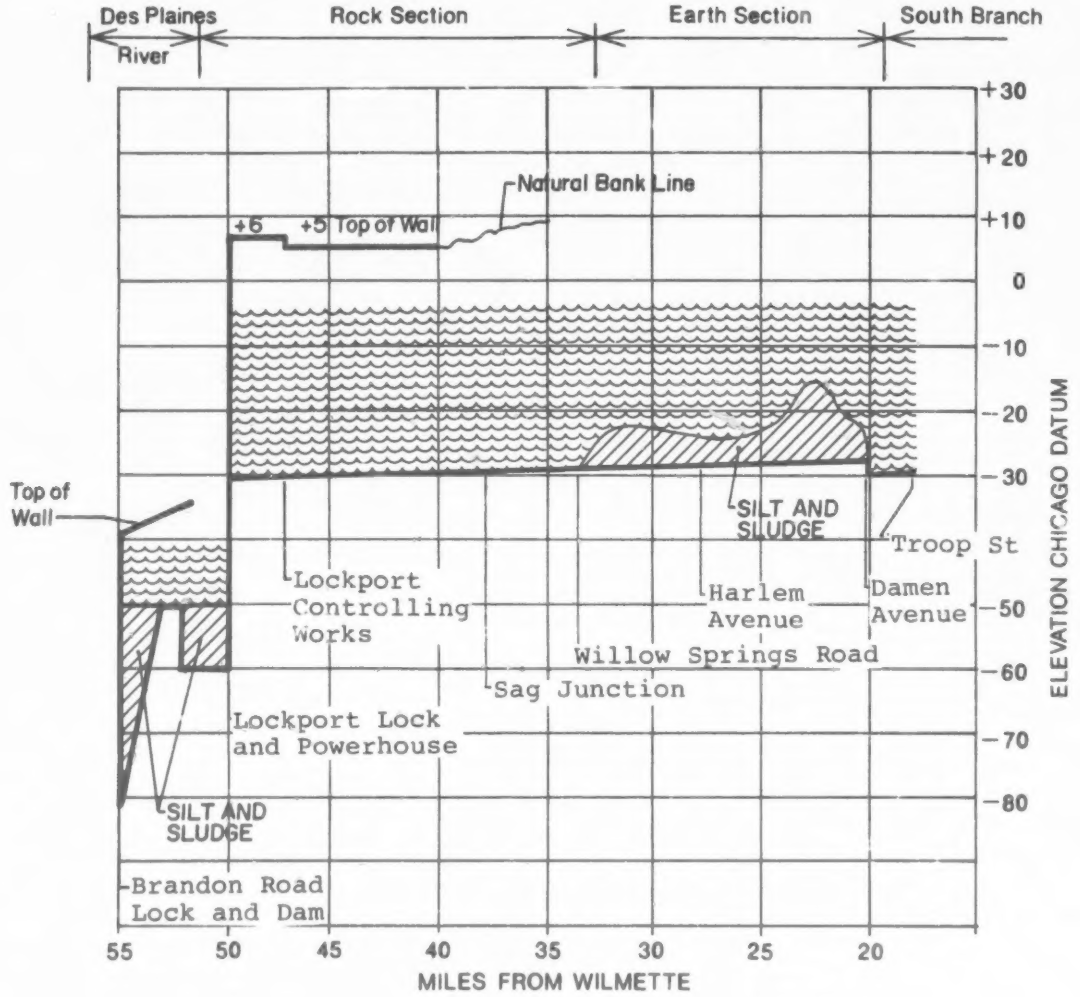
[1] MSDGC Environmental Assessment - Alternative management plans for control of flood and pollution problems due to combined sewer discharges in the general service area of the Metropolitan Sanitary District of Greater Chicago, November 1973, p. 114.

FIGURE II-5
Benthal Deposits in the Chicago
Sanitary and Ship Canal[1]



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[1] MSDGC - Alternative Management Plans for Control of Flood and Pollution Problems due to Combined Sewer Discharges in the General Service Area of the Metropolitan Sanitary District of Greater Chicago, November 1973, p. 129.

measured by the MSDGC as part of the bottom sampling program are shown in Figure A-1 of Appendix A. Sampling locations shown on the map are described in Table A-4 of Appendix A.

The full impact on water quality of sediment deposited during combined sewer overflow events is not always felt immediately. The stabilization of organic material deposited during the winter months is suppressed because of the cold temperatures. This ultimately results in heavy biological loading of the waterways during the summer months with the overdriving of the assimilative capacity of the rivers and streams. The intense demand for oxygen in the waterways during the warm months after leads to anaerobic conditions in the deposited material and septic or near-septic conditions do not meet minimum Illinois standards for restricted water use as described in Section 2.1.1, Surface Water Quality.

2.1.2 Groundwater

Quality and quantity of subsurface waters are of major importance to the construction and operation of the tunnel system. This section describes the groundwater regime of the Chicago area in Cook County.

(1) Physical Characteristics of Aquifers

1. General Hydrogeology

There are two main aquifer systems within the study area: the upper aquifer comprised of glacial drift and dolomites, and the lower (Cambro-Ordovician) aquifer comprised of dolomites and sandstones. Table II-5 summarizes the hydrogeology of the area. Unconsolidated Quaternary deposits and Silurian dolomites of the upper aquifer are hydraulically connected and function as a single water bearing unit, except in localized areas where impermeable strata separate them and perched water conditions exist. Clayey deposits in the glacial drift act as confining layers and thus create artesian conditions in the upper aquifer. Ordovician shales and dolomites of Maquoketa Group (on the average 150 feet thick) separate the upper and lower aquifers and act as an effective aquiclude.

Table II-5
Generalized Hydrology of the Chicago Area

System	Series or Group	Hydrology
Quaternary	Pleistocene	Upper Aquifer
Silucian	Niagaran Alexandrian	
Orduvician	Maquoketa	Aquiclude
	Galena	
	Platteville	
	Ancell	Lower Aquifer
	Prairie Du Chien	
Cambrian		

The lower aquifer includes dolomite and sandstone formations extending from the base of the Maquoketa Group to the top of the Eau Claire shales (Cambrian). Average thickness of the upper aquifer is on the order of 400 feet, while average thickness of the lower aquifer is about 1,000 feet.

2. Recharge-Discharge Relationships

Sources of groundwater recharge to the upper aquifer include infiltration of precipitation and influent streams. In general, response of water levels to precipitation is rapid. The lower aquifer is recharged in parts of McHenry, Kane, and DeKalb Counties where the Maquoketa aquiclude outcrops, containing appreciable dolomite, and further west where the Maquoketa has been removed by erosion. The lower aquifer has a lower potentiometric head then the upper aquifer; therefore, the lower aquifer is also recharged by leakage from the upper aquifer through confining layers of Maquoketa shales. Vertical permeability of the Maquoketa shales is about $5X10^{-5}$ gpd/ft^2. Walton[1] calculated that recharge to the lower aquifer in northeast Illinois is about 2,100 gpd/mi^2.

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[1] Walton, W.C., "Selected Analytical Methods for Well and Aquifer Evaluation," Illinois State Water Survey, Bulletin 49, 1962.

Groundwater is discharged primarily through pumpage; the greatest water level fluctuations are indicative of these withdrawals. Groundwater also discharges as base flow to streams and to Lake Michigan. In addition, a relatively small amount is consumed by evapotranspiration.

3. Water Levels - Areal and Temporal Character

A contour map of the potentiometric surfaces of the lower aquifer in the region around the study area is provided in Figure II-6. The figure indicates several significant cones of depression in the lower aquifer around major pumping centers in Cook County. Consequently, the direction of groundwater flow in the study area is toward these potentiometric depressions. Figure II-7, showing potentiometric contours of the upper aquifer, indicates that similar depressions occur in the vicinity of McCook and Thornton quarries, the locations proposed for storage of combined sewer overflows. These depressions are attributed to long-term quarry dewatering operations. Elsewhere, groundwater levels exhibit a low gradient.

Additional observations concerning upper aquifer water levels include the following:

"In the Chicago Central Business area (CBA), Lake Michigan appears to be recharging the aquifer, while a piezometric high in the area north of Belmont Avenue indicates the aquifer may be discharging into the lake. The lower water levels in the CBA probably result from dewatering operations in deep basements of commercial buildings. The groundwater contour configuration does not indicate that the Chicago River and the Chicago Sanitary and Ship Canal are hydraulically connected to the Upper Aquifer."[1]

With regard to temporal fluctuations in water levels, long-term records indicate that the most

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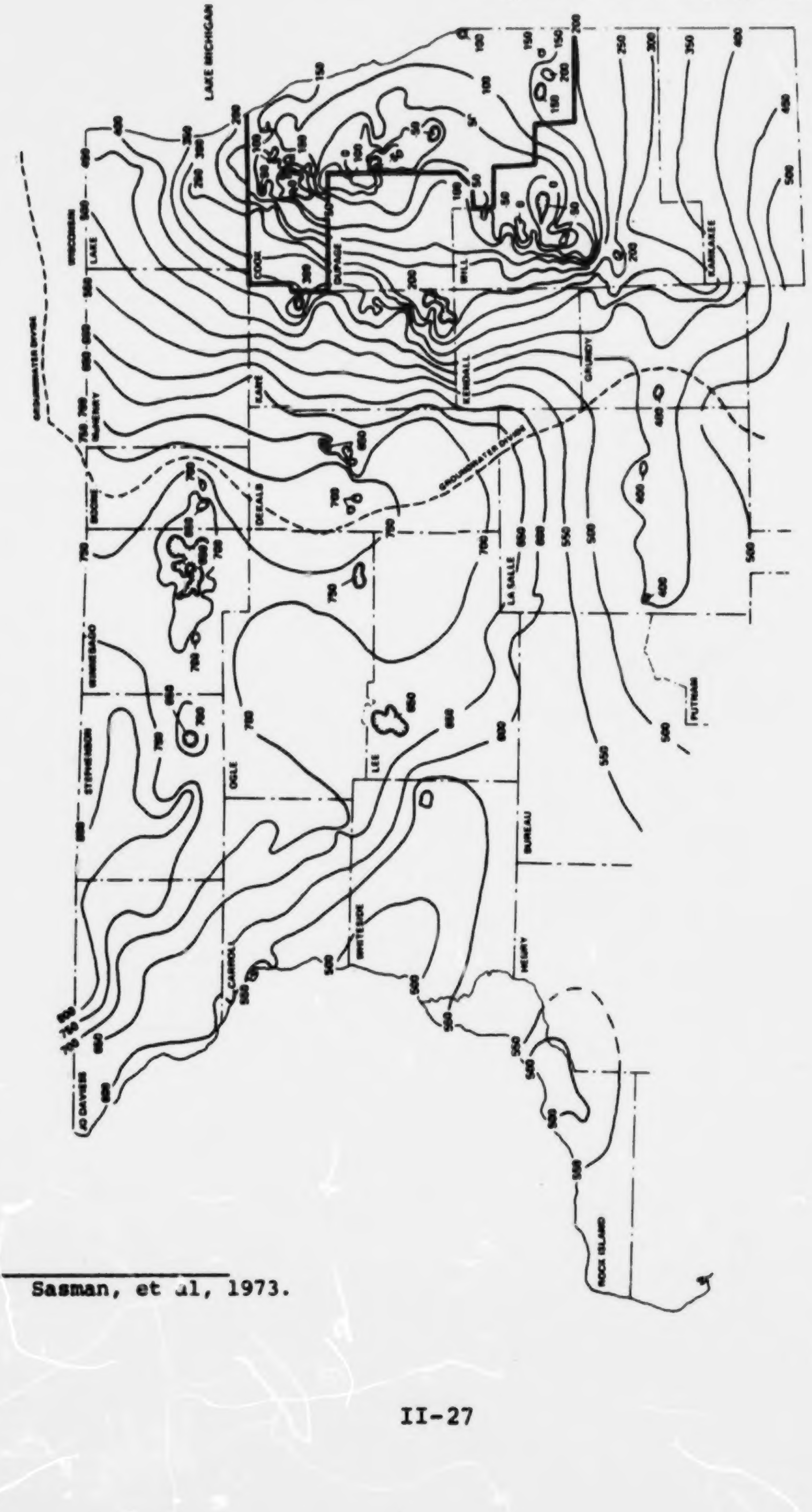
[1] Harza Engineering Company (HEC), Geotechnical Design Report: Tunnel and Reservoir Plan - Mainstream Tunnel System, August 1975.

FIGURE II-6
Elevation of Piezometric Surface of
Lower (Cambrian-Ordovician)
Aquifer in October 1971[1]


LAKE MICHIGAN
WISCONSIN
GROUNDWATER DIVIDE
LAKE
COOK
DUPAGE
WILL
KANKAKEE
McHENRY
KANE
KENDALL
GRUNDY
BOONE
DEKALB
LA SALLE
WINNEBAGO
STEPHENSON
OGLE
LEE
PUTNAM
BUREAU
JO DAVIESS
CARROLL
WHITESIDE
HENRY
ROCK ISLAND

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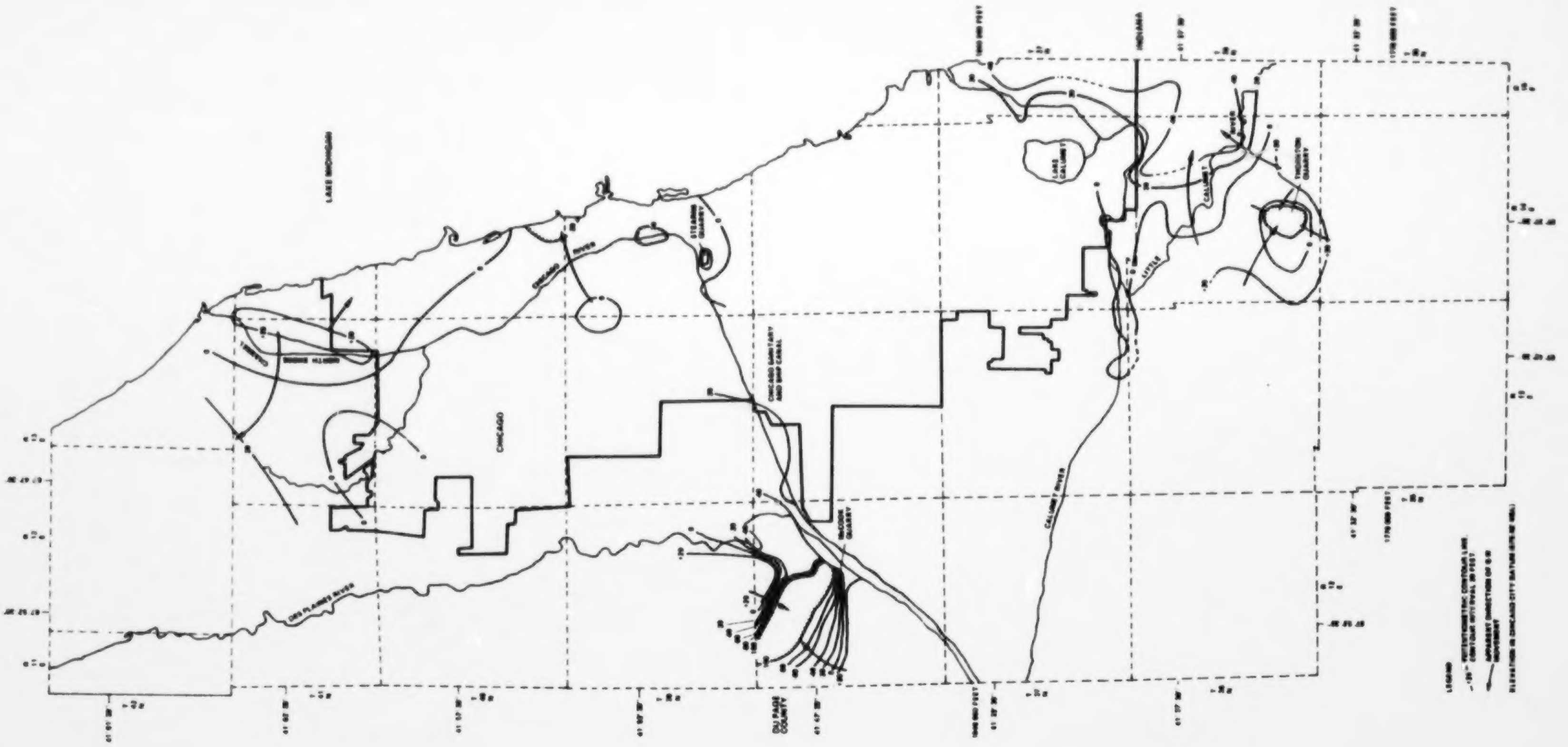
[1] Sasman, et al, 1973.

FIGURE II-7
Potentiometric Contour Map of Upper Aquifer, Eastern Cook County, December 1974[1]


LAKE MICHIGAN
CHICAGO
CHICAGO RIVER
STEARNS QUARRY
CHICAGO SANITARY AND SHIP CANAL
DU PAGE COUNTY
McCOOK QUARRY
DES PLAINES RIVER
CALUMET RIVER
LAKE CALUMET
INDIANA
LITTLE CALUMET RIVER
THORNTON QUARRY
1640 000 FEET
1770 000 FEET
LEGEND
POTENTIOMETRIC CONTOUR LINE
CONTOUR INTERVAL 20 FEET
APPARENT DIRECTION OF G.W. MOVEMENT
ELEVATION IN CHICAGO CITY DATUM

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[1] Harza Engineering Company (HEC), 1975.

significant trend has been an overall decline in water levels in the lower aquifer as a result of pumpage. The average decline was 15 feet per year for the period 1961 to 1966, and nine feet per year from 1966 to 1971.[1] Water levels declined in the upper aquifer between McCook Quarry and LaGrange about five feet annually due to aquifer overdevelopment.[2]

Seasonal fluctuations in water levels generally reflect climatological conditions as well as pumpage. For example, Harza Engineering Company points out that "... from March 1972 to March 1973, precipitation in the Chicagoland area was 33 percent above normal and the average rise of water levels in an 86-square-mile study area in the northeast part of Cook County was about 3.4 feet."[3] Generally, daily fluctuations in water levels reflect changes in the pumpage from production wells and changes in barometric pressure.

4. Aquifer Hydraulics

Flow of groundwater through the aquifers is largely controlled by secondary permeability, including joints, fractures, and bedding planes, thus hydraulic conductivity is variable spatially. Some of the openings in the dolomites have been solution-enlarged. Generally, primary permeability and porosity in the dolomites are very low. In both the upper and lower aquifers, permeability exhibits a decrease toward Lake Michigan. Silurian dolomites, for example, have permeabilities of 1 to 10^{-4} ft/min near the lake and increase westward to about 10 to 200×10^{-4} ft/min.

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[1] Sasman, R.T., C.R. Benson, G.L. Dzurisin and N.E. Risk, "Water-Level Decline and Pumpage in Deep Wells in Northern Illinois, 1966-1971," Illinois State Water Survey, Circular 113, 1973.

[2] HEC, 1975.

[3] Ibid.

Numerous aquifer tests have been conducted in the area along the proposed tunnel route, and various aquifer properties obtained from test wells about the McCook and Thornton Quarries are summarized in Tables II-6 and II-7. During aquifer testing, it was found that horizontal (bedding plane) permeability was significantly more pronounced than vertical (joint controlled) permeability.

According to Table II-6, the overall transmissivity of the lower aquifer (Cambro-Ordovician) is 22,400 gpd/ft. This value is lower than the sum of the transmissivities of individual units due to the hydraulic connection between the units. Additional testing in the Chicago area indicated that transmissivity of the lower aquifer ranged from 10,800 to 20,600 gpd/ft and averaged about 16,000 for 14 wells.[1]

Table II-7 points out the variable transmissivity of the dolomites in the upper aquifer. Values from 16 to 30,150 gpd/ft were obtained. This is typical of fracture and bedding place permeability conditions. Locations of the McCook and Thornton quarries are shown on Figure II-7.

5. Water Supply

Previous studies indicated that deep aquifers in Cook County are capable of producing about 25 MGD.[2] This value is based on an average aquifer thickness of 800 feet (above the top of the Ironton-Galesville formations of lower Cambrian age) and an average specific yield of 0.05. The upper aquifer in Cook County has a total potential yield of 108 MGD.[3] This is in keeping with previous

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[1] Suter, Max, et al., "Preliminary Report on Groundwater Resources of the Chicago Region, Illinois," State Water Survey and State Geological Survey, Cooperative Groundwater Report 1, 1959.

[2] Schicht, R.J., and Allen Moench, "Projected Groundwater Deficiencies in Northeastern Illinois, 1980-2020," Illinois State Water Survey, Circular 101, 1971.

[3] Schaeffer, R.R. and A.J. Zeizel, "The Water Resources in Northeastern Illinois," Illinois State Water Survey, Circular 101, 1966.

Table II-6
Permeabilities of Aquifers in the Chicago Area[1]

Aquifer	Geologic System	Series, Group or Formation	Thickness Ft.	Transmissibility gpd/ft.	Storage (HEC & Bauer Engineering, Inc., 1969)	Permeability	
						10^{-4} ft/min	10^{-4} cm/sec
Upper Aquifer	Silurian	Niagara-Alexandrian	394	400		1	0.5
Lower Aquifer	Cambrian-Ordovician		1,058	22,400		21	11
		Galena-Platteville	328	300		1	0.4
		Glenwood-St. Peter	91	500	0.00013	5	3
		Prairie du Chien, Eminence and Potosil	340	17,500	0.0005	50	24
		Franconia	127	5,500	0.0012	40	20
		Ironton-Galesville	172	15,200	0.000075	82	42

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[1] Harza Engineering Company, "Development of a Flood and Pollution Control Plan for the Chicagoland Area," Geology and Water Supply, Technical Report Part 4, December 1972.

Table II-7
Results of Tests in the Upper Aquifer[1]
(Silurian Dolomite)

Well Location	Type of Aquifer Test	Pumping Recharge or Inflow Rate (gpm)	1-Day Specific Capacity (gpm/ dd or Buildup in Feet)	Average Coefficient of Trans-missivity gpd/ft	Average Coefficient of Storage (Dimensionless)	Remarks	Permeable Zones	Depth
NW side of McCook Quarry	Pumping Recharge Recharge	400 505 790	11.5 10.5 1/ 5.5 1/	30,150	1.4×10^{-4}	Widespread homogeneous conditions	Upper half of Edgewood Formation, lower Racine thru Romeo and Markgraf Members	290-340' 210-255
SW side of McCook Quarry	Bail	5	-	190	4.0×10^{-5}		Limited, sporadic zones in Racine Formation (interreef)	45-98
NE side of McCook Quarry	Pumping	62	0.7	1,780	1.0×10^{-5}	Polluted water, negative boundary about 1/2 mile S of site	Interreef of Racine middle Edgewood Romeo-Markgraf contact	110-120 307-317 182-192
SE corner of McCook Quarry	Pumping	42	0.4	295	1.3×10^{-5}	Slight leaky aquifer conditions, no hydraulic connection w/river; coefficient of leakage through aquitard ave. 0.00062 gpd/ft^2	Lower Kankakee down 75' thru most of Deadwood (extremely permeable)	
1 mile NE of McCook Quarry	Bail	15	-	530	1.0×10^{-4}	Partially penetrating monitoring well	Upper Silurian dolomite	65-133 and 149-154
1 mile south of Thornton Quarry	Bail	2.5	-	16	1.0×10^{-4}		Interreef Racine	Upper 100'
1/2 mile west of Thornton Quarry	Pumping	440 Av.	3.8	18,900	2.4×10^{-4}	At least two negative boundaries close to test well	Racine reef	Top of rock -240' and 100-140 @ test well

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[1] HEC, 1975.

calculations showing a potential yield of 92 MGD for the Silurian dolomites of the upper aquifer and 6 MGD for the glacial sand and gravel sediments.[1]

Groundwater use in the area has been extensive and deficiencies are predicted for the future. In 1970, pumpage from glacial sand and gravel was about 3 to 4 MGD and about 36.5 MGD from shallow dolomites. Therefore, about 59 percent of the total potential yield was undeveloped. Pumpage of the lower aquifer, however, was more extensive and exceeded practical sustained yield in the vicinity of Summit by 2.3 times. By 1966, water levels in the Chicago, Des Plaines, and Elmhurst pumping centers had declined below the top of the lower (Cambro-Ordovician) aquifer resulting in some dewatering of the Galena-Platteville strata. Figures II-8 and II-9 indicates groundwater deficiencies that will result if water demands projected through the year 2020 are realized. Obviously, groundwater conservation and management are a necessity for future optimum use of available water supplies.

(2) Chemical Characteristics of Groundwater

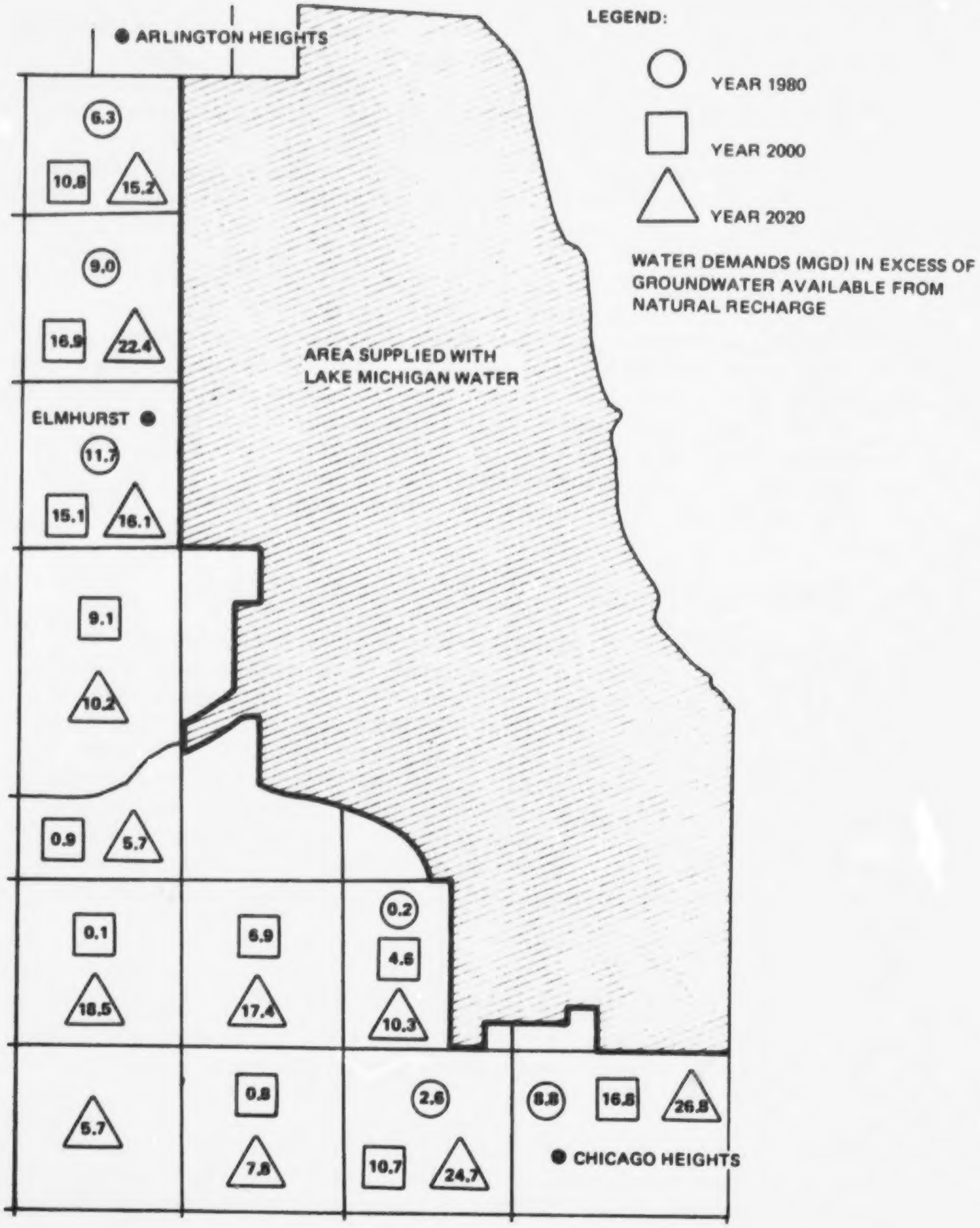
Tabulated water quality data from test wells in the study area, representing both the upper and lower aquifers,[2] is presented in Table A-5 of Appendix A. It can be seen that several constituents in the upper Silurian aquifer (e.g., Fe, SO_4, and turbidity) are highly variable. Water from Galena-Plateville strata (lower aquifer) has a higher mineral content and more uniform water quality characteristics than the upper aquifer. Water quality from different geologic series throughout the lower aquifer do not change considerably with depth.

---

[1] Moench, A.F. and A.P. Visocky, "A Preliminary Least Cost Study of Future Groundwater Development in Northeast Illinois," Illinois State Water Survey, Circular 101, 1971.

[2] Buschbach, T.C. and George E. Heim, "Preliminary Geologic Investigations of Rock Tunnel Sites for Flood and Pollution Control in the Greater Chicago Area," Illinois State Geological Survey Environmental Geology Notes, Number 52, 1972.

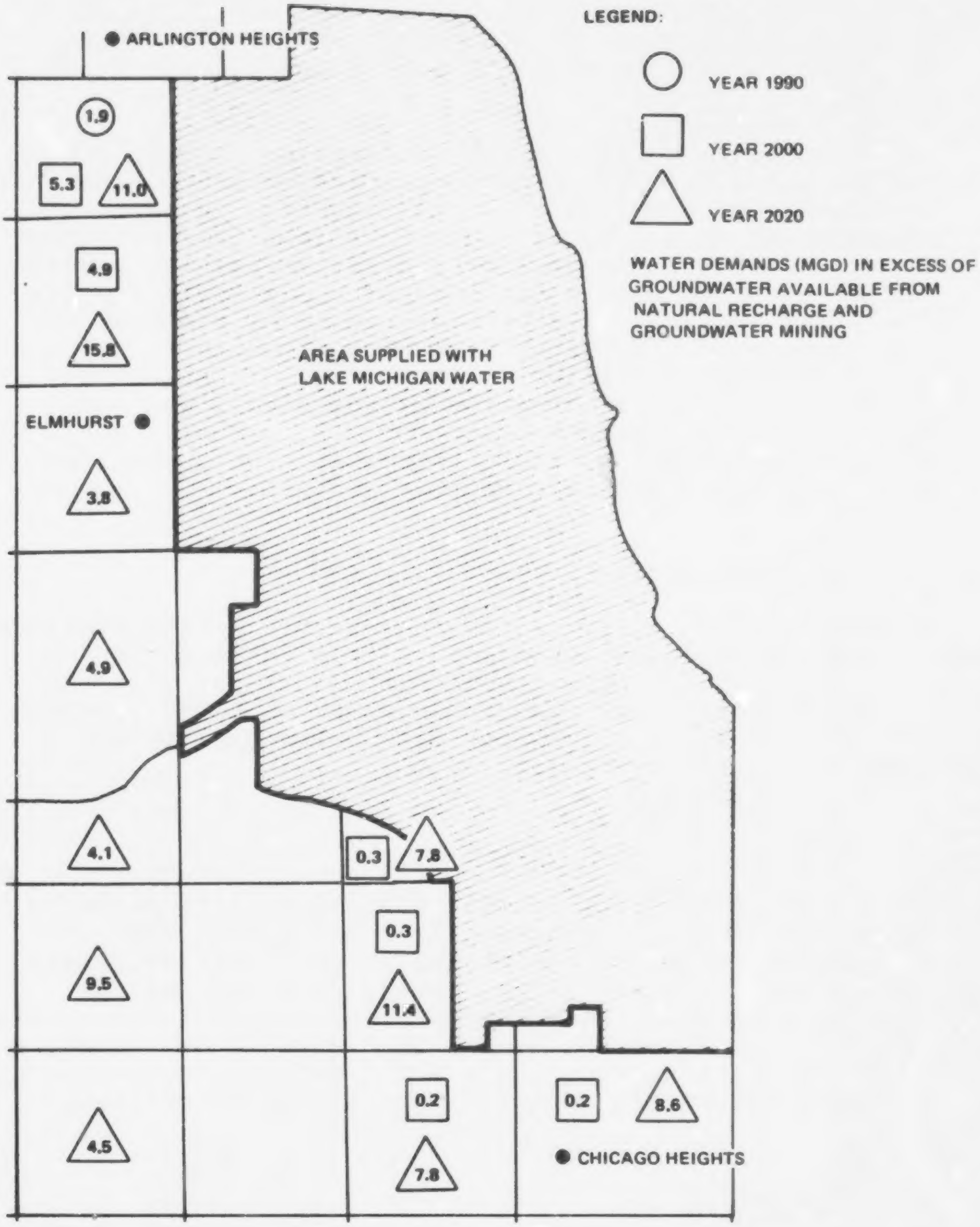
FIGURE II-8
Projected Groundwater
Deficiencies[1]-Natural Recharge


LEGEND:
YEAR 1980
YEAR 2000
YEAR 2020
WATER DEMANDS (MGD) IN EXCESS OF GROUNDWATER AVAILABLE FROM NATURAL RECHARGE
ARLINGTON HEIGHTS
ELMHURST
CHICAGO HEIGHTS
AREA SUPPLIED WITH LAKE MICHIGAN WATER
6.3
10.8
15.2
9.0
16.9
22.4
11.7
15.1
16.1
9.1
10.2
0.9
5.7
0.1
18.5
6.9
17.4
0.2
4.6
10.3
5.7
0.8
7.8
2.6
10.7
24.7
8.8
16.8
26.8

---

[1] Schicht and Moench, 1971.

FIGURE II-9
Projected Groundwater Deficiencies[1] - Natural Recharge and Mining


LEGEND:
YEAR 1990
YEAR 2000
YEAR 2020
WATER DEMANDS (MGD) IN EXCESS OF GROUNDWATER AVAILABLE FROM NATURAL RECHARGE AND GROUNDWATER MINING
ARLINGTON HEIGHTS
1.9
5.3
11.0
4.9
15.8
ELMHURST
3.8
AREA SUPPLIED WITH LAKE MICHIGAN WATER
4.9
4.1
0.3
7.8
9.5
0.3
11.4
4.5
0.2
7.8
0.2
8.6
CHICAGO HEIGHTS

---

[1] Schicht and Moench, 1971.

Water in the lower (Cambro-Ordovician) aquifer demonstrates increasing hardness eastward in the study area from about 350 ppm in the vicinity of the Des Plaines River to about 600 ppm at the lake.[1] In this same area, chloride concentrations also show west to east increases from about 40 ppm at the river to 150 ppm at the lake.[2]

During late 1974, Harza Engineering Company conducted water quality tests on samples obtained from test wells penetrating the upper aquifer. Results of these analyses are summarized in Table A-6 of Appendix A. The concentrations of many constituents are greater and more variable than those reported in Table A-5 for the upper aquifer. With the exception of the test well located on the NE side of McCook Quarry (see Figure II-6), water samples are hard, and of the calcium sulfate type. Water from the excepted well was polluted with high concentrations of COD, ammonia, surfactants, metals, and coliform bacteria. The postulated source of pollution is a nearby landfill.

2.1.3 Pollution Sources

Surface water quality in the area served by the combined-sewer system is dependent upon inputs from three major sources; sanitary outfalls, industrial waste outfalls and combined-sewer overflows. Characteristics of these sources of input and the implications for area water quality are discussed in the following sections.

(1) Municipal Waste Loads

Six wastewater treatment facilities are currently in operation within the MSDGC service area. They are Streamwood, Hanover, Lemont, Northside, West-Southwest and Calumet. Location for these plants and for the John E. Egan Water Reclamation Plant, which is currently under construction, are shown in Figure II-10. Outfalls from the existing facilities are adjacent to the plants. Characteristics of the existing treatment facilities,

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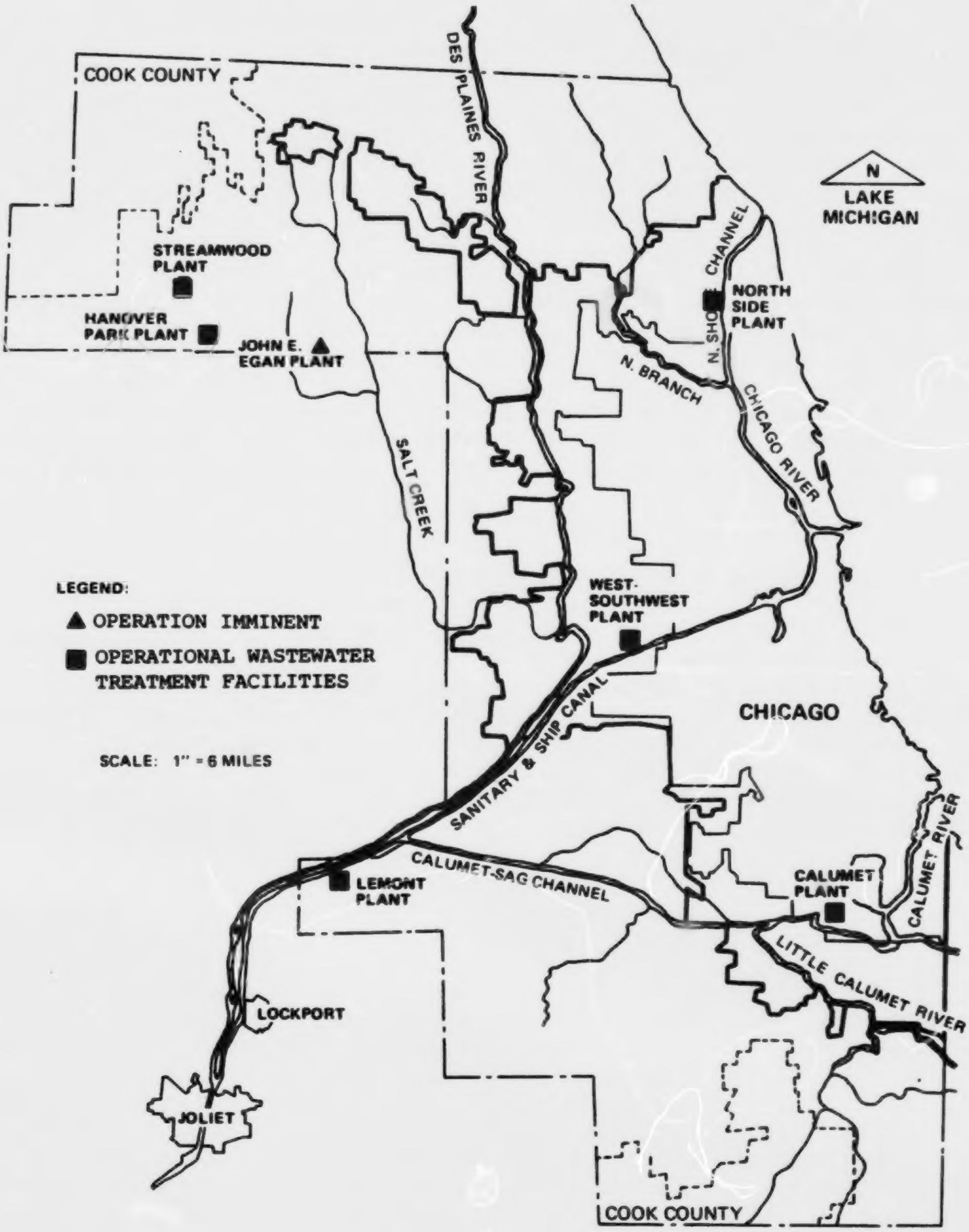
[1] Suter, et al, 1959.

[2] Ibid.

FIGURE II-10
Locations of MSDGC
Wastewater Treatment
Facilities


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
STREAMWOOD PLANT
HANOVER PARK PLANT
JOHN E. EGAN PLANT
N. SHORE CHANNEL
NORTH SIDE PLANT
N. BRANCH
CHICAGO RIVER
SALT CREEK
LEGEND:
▲ OPERATION IMMINENT
■ OPERATIONAL WASTEWATER TREATMENT FACILITIES
SCALE: 1" = 6 MILES
WEST-SOUTHWEST PLANT
CHICAGO
SANITARY & SHIP CANAL
CALUMET RIVER
CALUMET-SAG CHANNEL
LEMONT PLANT
CALUMET PLANT
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY

including the receiving stream, the average flow for 1973, and the average influent and effluent concentrations of BOD, SS, and ammonia nitrogen are presented in Table II-8.

The largest treatment plants; West-Southwest, Northside and Calumet, provide preliminary, primary and secondary treatment using chlorination and post-aeration. Hanover, Lemont and Streamwood provide preliminary, primary, secondary and tertiary treatment using chlorination and post-aeration. The John E. Egan plant, presently nearing operation, will also provide tertiary treatment.

Both BOD and SS concentrations easily meet the Federal guidelines of 30 mg/1 (roughly equivalent to 30 ppm) for each. Although more stringent Illinois discharge standards for BOD, SS and ammonia nitrogen (see Table II-8) do not have to be met until December 31, 1977, most of the MSDGC plants are already in compliance with the BOD and SS standards, 10 mg/1 and 12 mg/1, respectively, and two plants better the ammonia nitrogen standard.

(2) Industrial Waste Loads

Industrial waste flows sent to MSDGC treatment plants total about 195 MGD, broken down as follows: 135 MGD to the West-Southwest facility, 22 MGD to the Northside facility and 38 MGD to the Calumet plant. In addition there are other industrial and privately-owned treatment plants which discharges in the area as shown in Figure A-2 of Appendix A. Discharges from these sources are subject to the MSDGC Sewage and Waste Control Ordinance and must meet the State of Illinois effluent discharge standards shown in Table II-1.

(3) Combined Sewer Overflows

Chicago area waterways are subject to increased pollutant inputs from the combined sewers during periods of overflow. Rainfall runoff in excess of about 0.1 inches leads to discharge of raw sewage and runoff at about 645 outfalls in the area. Such events occur approximately 100 times per year, injecting BOD, SS, grease, pathogenic organisms and other pollutants into the waterways in large quantities. During such events minimum Illinois standards for restricted use waters are not met.

Table II-8

Pollutant Removal Efficiencies of MSDGC Wastewater Treatment Plants - 1973[1]

Plant	Receiving Stream	Average Flow	Average BOD			Average Suspended Solids			Ammonia Nitrogen		
		(MGD)	Influent (ppm)	Effluent (ppm)	% Reduction	Influent (ppm)	Effluent (ppm)	% Reduction	Influent (ppm)	Effluent (ppm)	% Reduction
West-South-West	Sanitary and Ship Canal	866	183	7	96%	222	9	96%	7.3	7	4%
North side	North Shore Channel	344	115	10	91%	126	13	90%	10.5	5	52%
Calumet	Calumet River	210	145	15	90%	122	12	90%	20.8	18	13%
Hanover	Salt Creek	5.6	164	3	98%	202	5	98%	16.1	1	94%
Streamwood	Poplar Creek	2.4	132	9*	93%	178	16*	91%	Not Avail.	12	-
Lemont	Sanitary and Ship Canal	0.9	184	2	99%	282	3	99%	9.1	0.2	98%

* Average of last six months of 1973 after plant modifications

[1] "Facilities Planning Study - MSDGC Overview Report," revised Janauary 1975, pp. M-V-2, 4.

Beyond the immediate impact of the combined-sewer overflow are long-term effects on water quality. Sewage solids that settle in the waterways eventually decompose liberating BOD in the stream and decreasing the dissolved oxygen (DO) content of the waters. The stabilization of sewage solids is suppressed during the cold months so that the maximum impact on the waterways results in the summer months when other pollutant loadings are also high. Figures II-11, 12, and 13 show DO profiles developed by the MSDGC which simulate existing dry weather conditions in the North Shore Channel and North Branch of the Chicago River, in the Chicago River and Sanitary and Ship Canal, and in the Calumet River and Calumet-Sag Channel. 1977 Illinois standards for DO are shown with each figure. Maintenance of DO concentrations at mandated levels during the critical summer months is possible only if benthal loads deposited during combined-sewer overflow episodes are eliminated. The magnitude of the problems is so great that combined-sewer overflows constitute the largest obstacle to attaining state water quality standards. Estimates of BOD released to area waterways during the approximately 100 yearly overflow occurrences indicate that on an average basis BOD from sewer overflow nearly equals the total BOD output for all six MSDGC treatment plants.[1]

2.1.4 Water Management Programs

Management of area water resources in a manner that will develop their multiple uses fully is being addressed in the Chicago area by a variety of programs ranging from regional to local in focus. These programs and their interface with the Tunnel and Reservoir Plan are discussed briefly below.

(1) The Chicago Metropolitan Area River Basin Plan (CMARBP)

The CMARBP plan is concerned with stopping pollution of the Chicago Basin and with developing management strategy to meet water quality goals. The basin plan will assess the extent of pollution in the basin's waters and define the nature and volume of pollutants that can be discharged without pushing water quality below certain minimum standards. The plan will also

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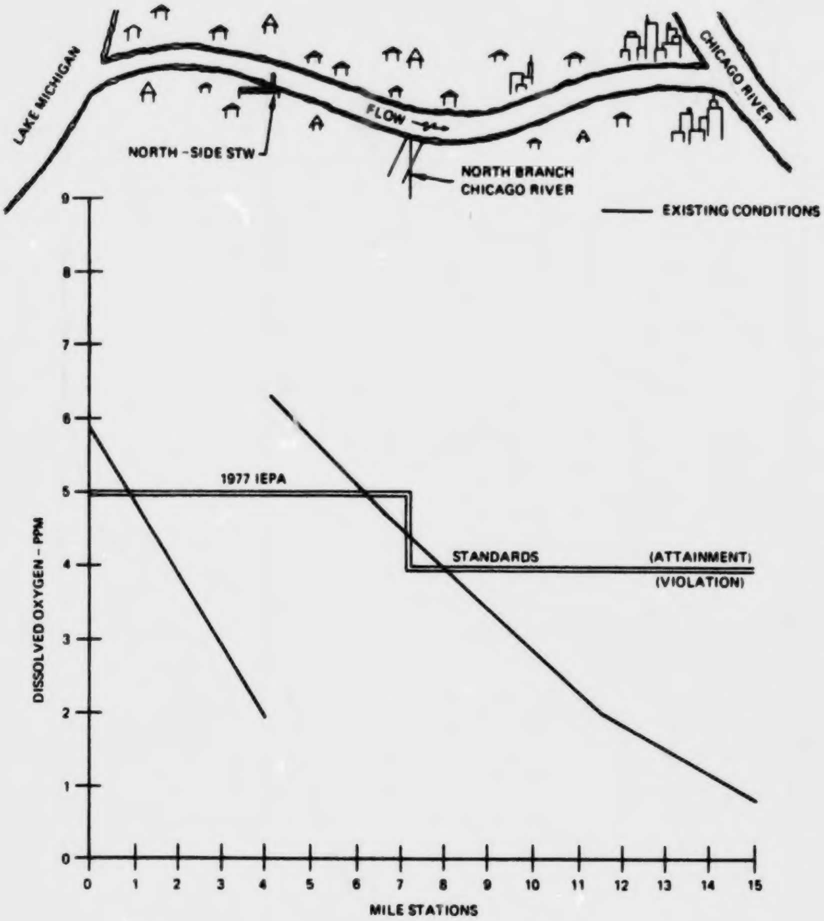
[1] Hearing on the Proposed Chicago Tunnel and Reservoir Plan, Chicago, Illinois, March 28, 1974.

FIGURE II-11
Simulation of Dissolved Oxygen Concentrations Under Existing Conditions Along North Shore Channel[1]



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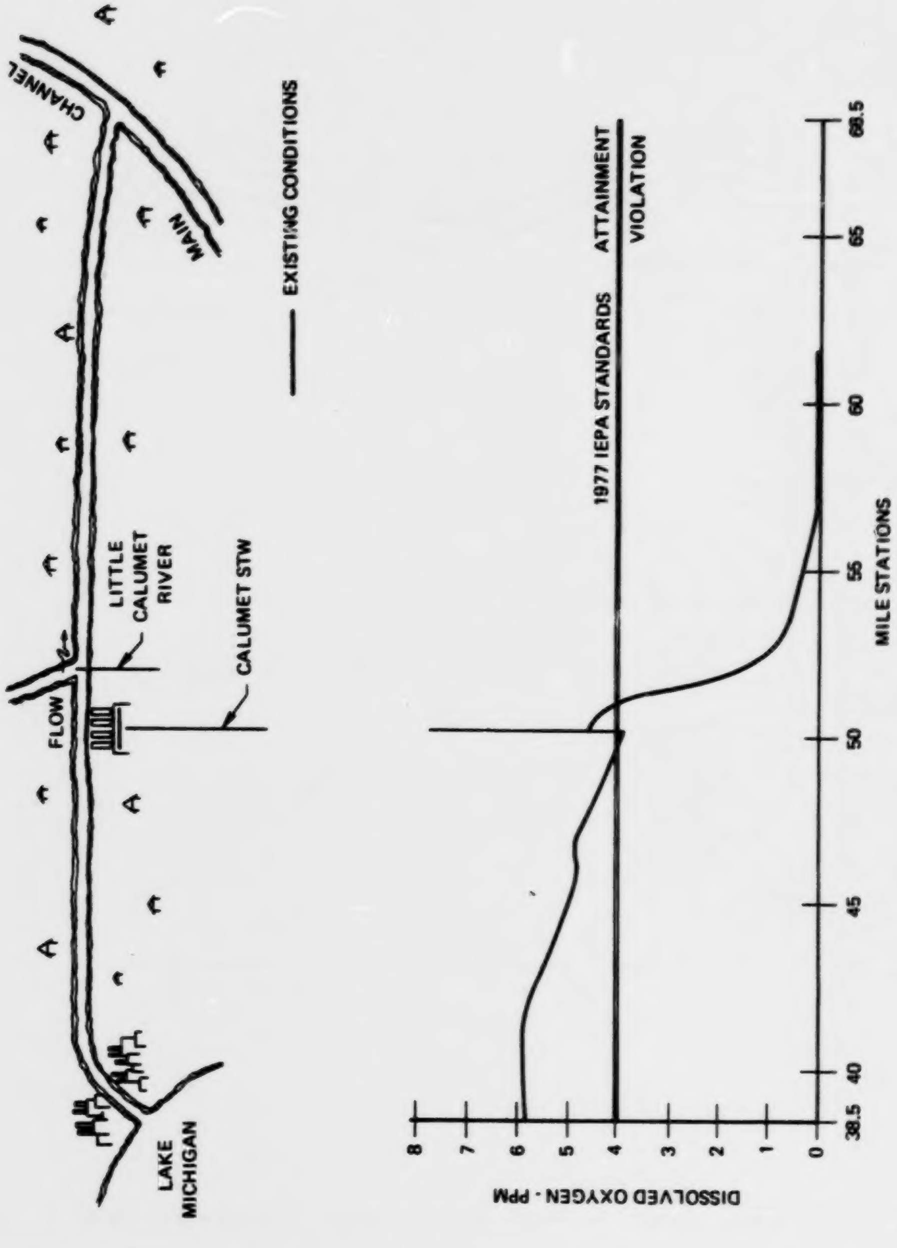
[1] J. Irons, MSDGC, Personal Communication, February 10, 1976.

FIGURE II-12
Simulation of Dissolved Oxygen Concentrations Under Existing Conditions Along Calumet River System[1]



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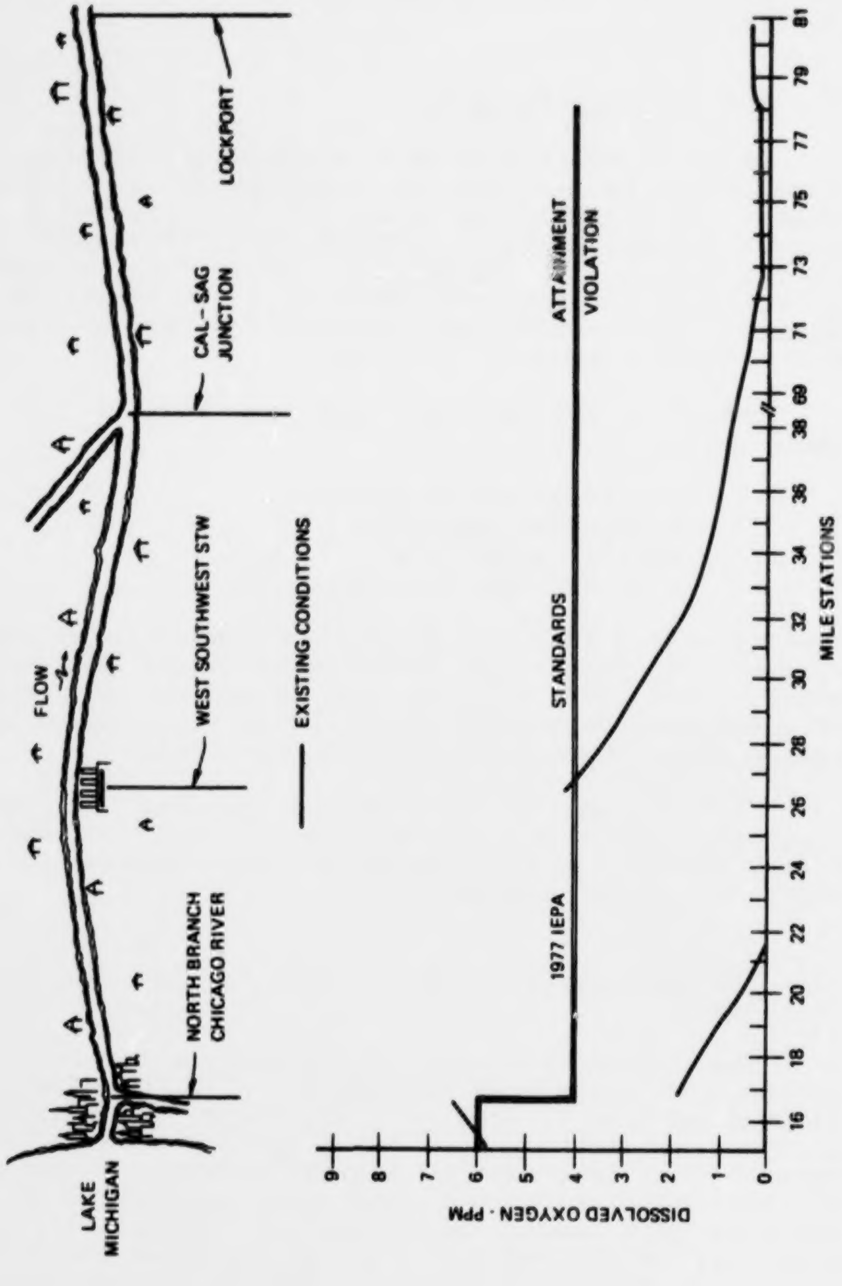
[1] J. Irons, MSDGC, Personal Communication, February 10, 1976.

FIGURE II-13
Simulation of Dissolved Oxygen Concentrations Under Existing Conditions Along Chicago River - Sanitary and Ship Canal[1]



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[1] J. Irons, MSDGC, Personal Communication, February 10, 1975.

establish priorities for the construction and modification of treatment plants. Principal agencies in this study are the U.S. Soil Conservation Service and the MSDGC. The plan explicitly recognizes the need for TARP as part of a larger plan for upgrading water quality.

(2) 208 Planning Program

Areawide waste treatment management planning required under Section 208 of PL 92-500 is just commencing at the present time under the direction of Northeastern Illinois Planning Commission (NIPC) which is the designated planning agency. Their work is expected to culminate in about two years in a comprehensive regional report which will address the several management efforts currently underway.

Under the 208 Program, sampling projects will be conducted to assess:

- In-stream water quality
- Floodwater pollution
- Benthic conditions
- Fish species diversity.

Data generated from the 45 in-stream monitoring stations will provide input to a computerized water quality model. This model will be used to project the impact of additional development and system response to suggested water resource management strategies.

The regional overview gained from the 208 Planning Program is expected to provide additional documentation of the need for planned waterway improvements, of which TARP is a major component.

(3) The Chicago-South End of Lake Michigan (C-SELM) Study

The C-SELM Study represents yet another regional approach to wastewater management. C-SELM addresses various methods to treat all wastewater flows in its study area. Methods considered include advanced physical/chemical treatment of wastes, advanced techniques for biological treatment, and spray irrigation of effluent in a land disposal system. Compatibility with TARP is assured since the study makes the basic assumption that an underground conveyance and storage system would be adopted.

(4) Thornton Quarry Flood Control Project

The U.S. Soil Conservation Service is currently considering using a portion of Thornton Quarry as a flood reservoir. Peak flows would be routed from Thorn Creek on the region's far south side to the quarry. TARP would also use the quarry to store combined-sewer overflows for treatment. Different areas of the quarry and separate facilities will be employed so that the projects will be compatible and complementary.

(5) City of Chicago Sewer Construction Program

Auxiliary outlet sewers are planned for areas within the city as well as for some suburban communities. This program will increase the conveyance capacity of the local tributary area sewer system. TARP is designed to accommodate the projected increased flow rate, however.

(6) Area Treatment Plant Upgrading and Expansion

As part of its effort to improve water quality, the MSDGC plans significant upgrading and expansion of existing wastewater treatment plants. Modification of the West-Southwest, North-Side and Calumet plants is proposed as an integral part of the effort to meet Illinois standards.

(7) Des Plaines River Watershed - Floodwater Management Plan

This program is being carried out under the sponsorship of the U.S. Soil Conservation Service and the MSDGC. The plan affects the Des Plaines River and its tributary streams. Significant aspects include:

- A land treatment program
- Flood plain management
- Construction of flood-retarding structures.

(8) Du Page County - Salt Creek Study

This plan, sponsored by the Forest Preserve District of Du Page County and the Illinois Division of Water Resources, was developed for flood prevention along Salt Creek. It employs land use zoning and the construction of flood-retaining structures.

(9) Addison Creek Improvements

The Illinois Division of Water Resources plans the construction of a retention reservoir near George Street and a channel bypass from a point near where the creek enters Cook County to the vicinity of Mannheim Road. Four flood-retention reservoirs would ultimately be constructed.

(10) Dredging of Illinois Waterways

The U.S. Army Corps of Engineers currently performs regular maintenance dredging of the major river systems in the MSDGC's service area. The dredging of oxygen-depleting wastes in the waterways is important in the upgrading of dissolved oxygen concentrations in the waterways.

(11) Lakefront Plan

The city of Chicago's ambitious Lakefront Plan calls for extensive new recreational improvements along lake shore. Development alternatives include:

- Expanding the park base through shoreline extension
- Expanding the park base through shoreline extension and creation of sheltered water areas either through the use of peninsulas or through the construction of off-shore breakwaters
- Expanding the park base through the development of islands as well as shoreline extensions.

Enhanced use of the waterways is an essential part of the plan, contingent upon water quality improvements largely as a result of TARP. The broader aspects of the plan are discussed in Section 3.2, Land Use.

2.2 LAND RESOURCES

The following section describes the land resources of the Chicago metropolitan area, and is divided into separate discussions of drainage basins, flood prone areas, geology, and seismicity.

2.2.1 Drainage Basins

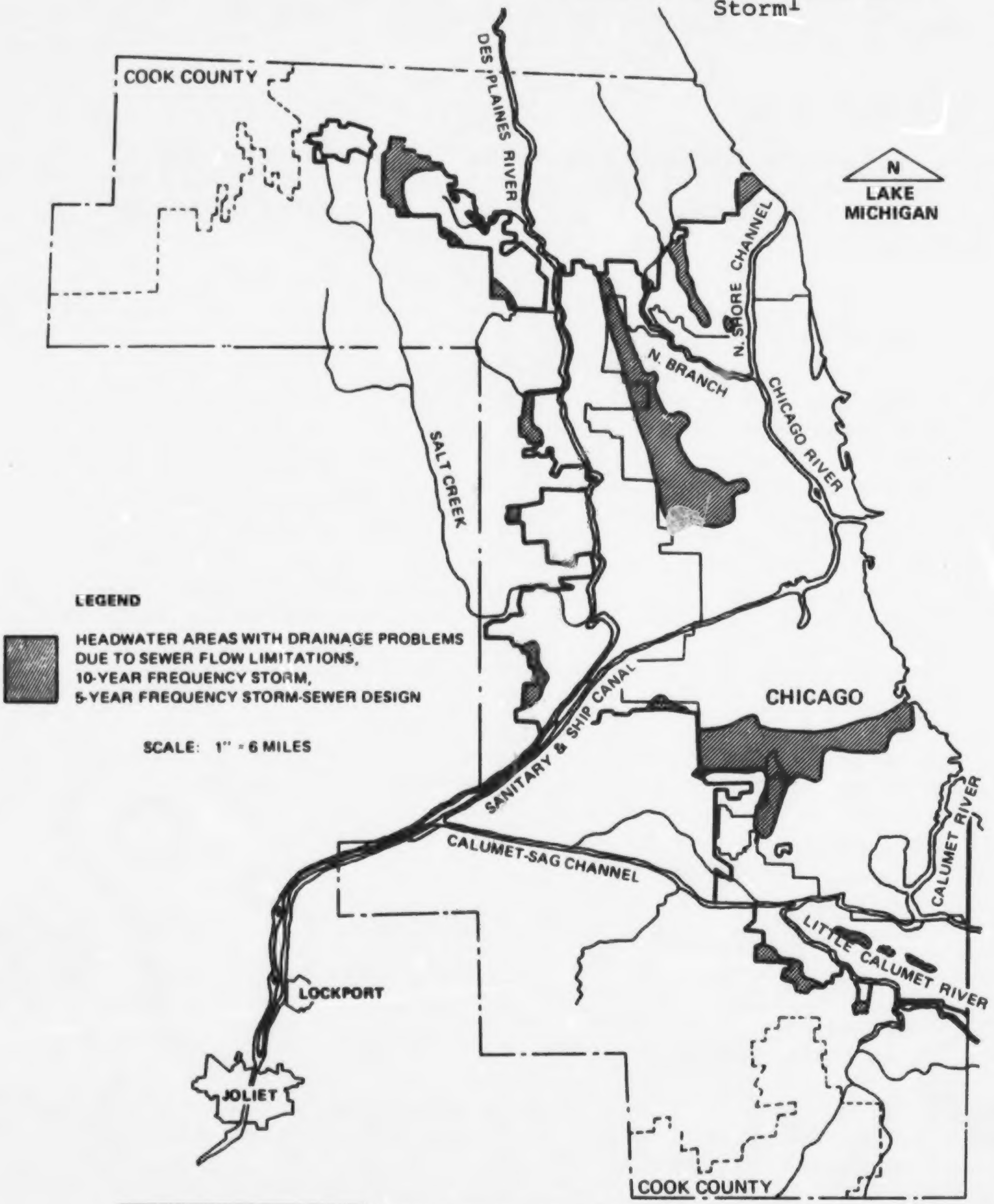
Construction of the Sanitary and Ship Canal in 1900 and the Calumet-Sag Channel in 1922 significantly altered drainage patterns around Lake Michigan. Drainage from an area of about 70 square miles north of downtown Chicago and along Lake Michigan previously flowed to Lake Michigan. Now, however, this drainage feeds the Illinois waterways via the Chicago River - Sanitary and Ship Canal System. In addition, reversal of water flow through the Calumet-Sag Channel has diverted normal flow from the area around Lake Calumet away from Lake Michigan and into the Illinois waterways. Ultimately, the Illinois Waterway System flows into the Illinois River along with two other large tributaries, the Des Plaines River and the Du Page River.

The overall low relief of the combined-sewer system area makes it prone to flooding from sewer system backups. The sewer system is designed to contain a five-year storm. Total land area flooded by storms larger than present sewer capacity is given below:

Event	Size of Flooded Area (Sq.Mi.)
Ten Year Storm	50
Twenty-five Year Storm	161
Fifty Year Storm	210
One Hundred Year Storm	254

Figures II-14 through II-17 show graphically the spread of flooding throughout the combined-sewer system area as a result of successively larger storms.

FIGURE II-14
Areas with Drainage
Problems During 10-Year
Storm[1]


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
N. SHORE CHANNEL
N. BRANCH
CHICAGO RIVER
SALT CREEK
LEGEND
HEADWATER AREAS WITH DRAINAGE PROBLEMS DUE TO SEWER FLOW LIMITATIONS, 10-YEAR FREQUENCY STORM, 5-YEAR FREQUENCY STORM-SEWER DESIGN
SCALE: 1" = 6 MILES
SANITARY & SHIP CANAL
CHICAGO
CALUMET RIVER
CALUMET-SAG CHANNEL
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY

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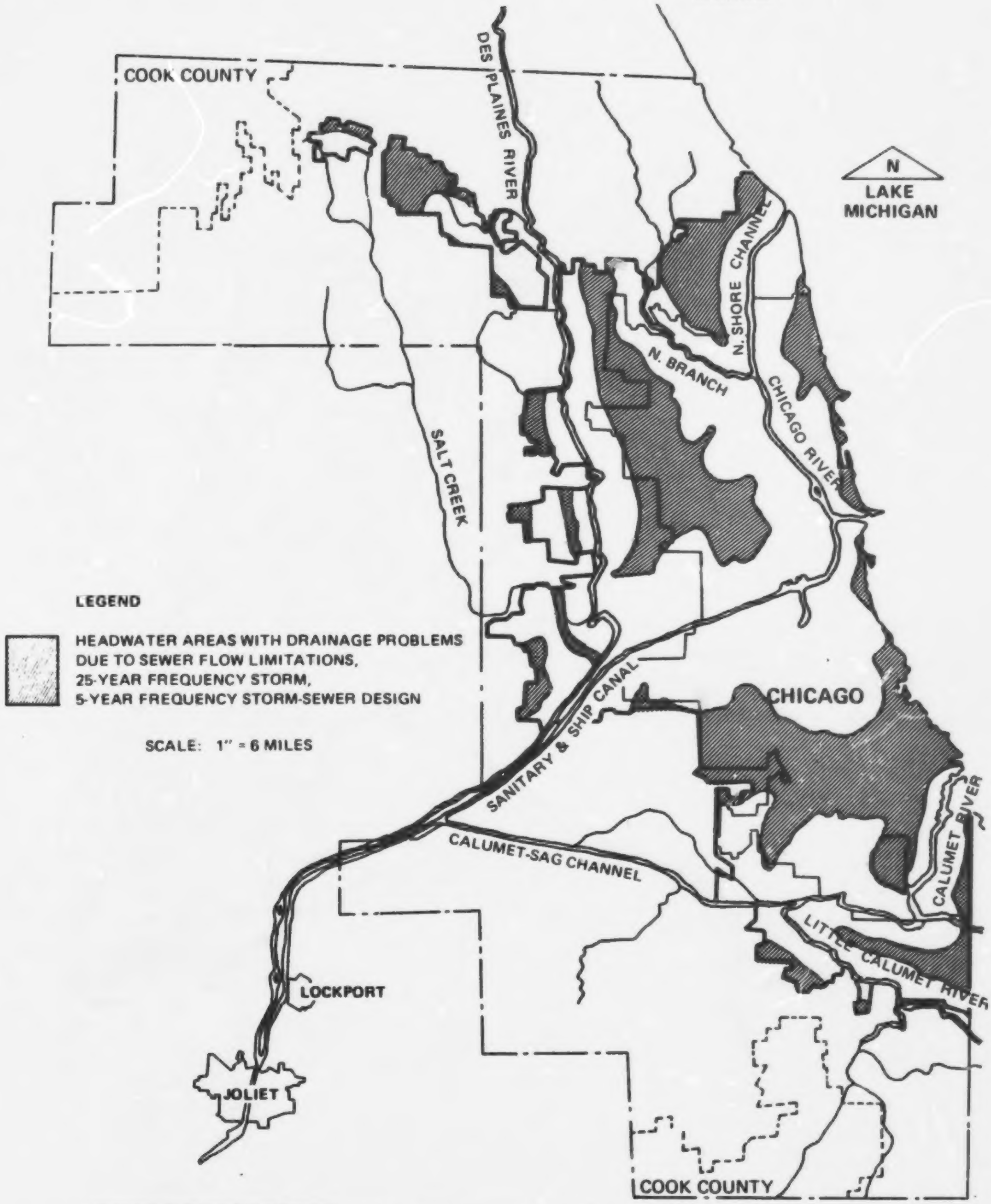
[1] MSDGC Environmental Assessment - Alternative management plans for control of flood and pollution problems due to combined sewer discharges in the general service area of the Metropolitan Sanitary District of Greater Chicago, November 1973, pp. 105-108.

FIGURE II-15
Areas with Drainage
Problems During 25-Year
Storm[1]


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
N. SHORE CHANNEL
N. BRANCH
CHICAGO RIVER
SALT CREEK
LEGEND
▨ HEADWATER AREAS WITH DRAINAGE PROBLEMS DUE TO SEWER FLOW LIMITATIONS, 25-YEAR FREQUENCY STORM, 5-YEAR FREQUENCY STORM-SEWER DESIGN
SCALE: 1" = 6 MILES
CHICAGO
SANITARY & SHIP CANAL
CALUMET RIVER
CALUMET-SAG CHANNEL
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY

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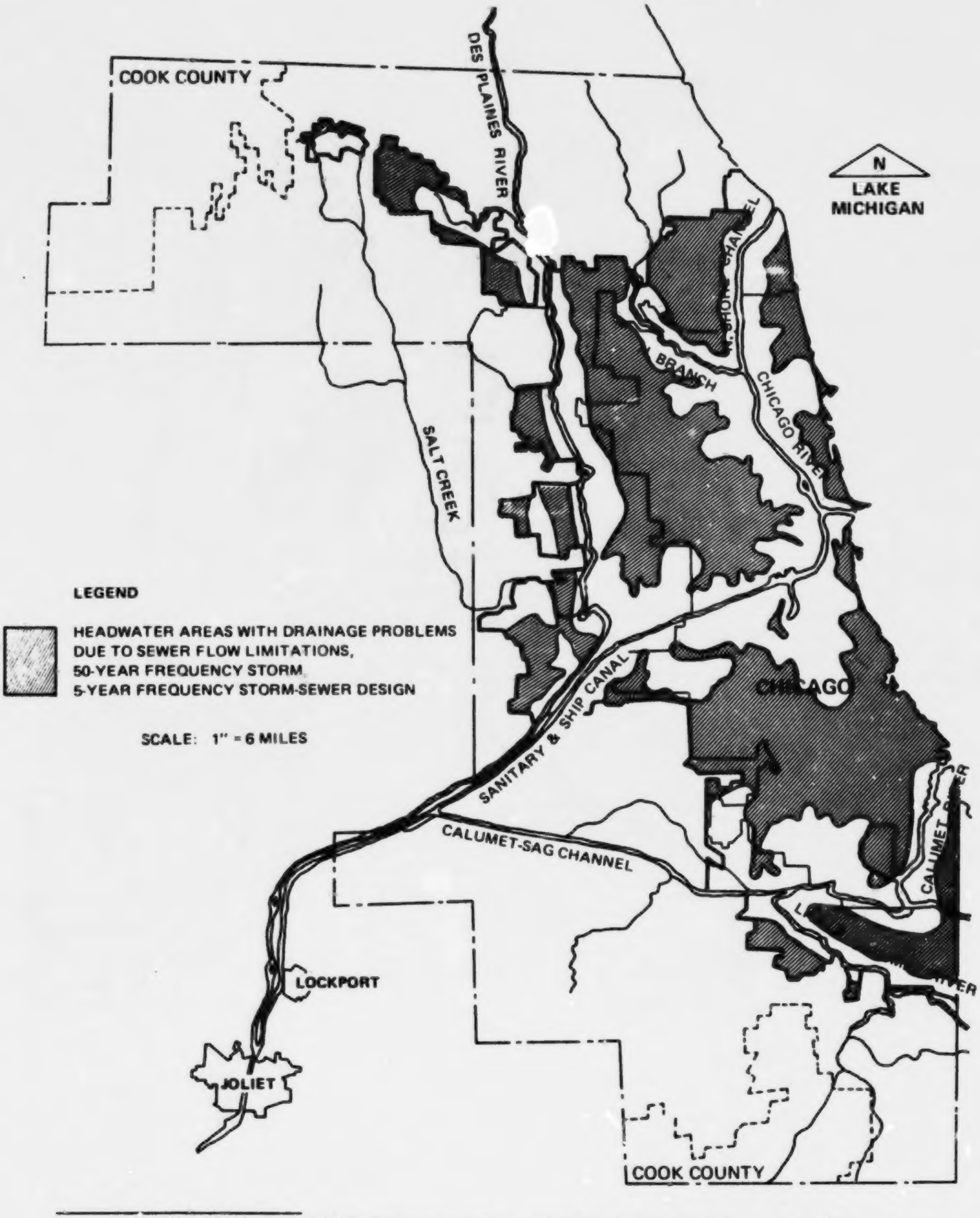
[1] MSDGC Environmental Assessment - Alternative management plans for control of flood and pollution problems due to combined sewer discharges in the general service area of the Metropolitan Sanitary District of Greater Chicago, November 1973, pp. 105-108.

FIGURE II-16
Areas with Drainage
Problems During 50-Year
Storm[1]


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
N. SHORE CHANNEL
N. BRANCH
CHICAGO RIVER
SALT CREEK
LEGEND
▨ HEADWATER AREAS WITH DRAINAGE PROBLEMS DUE TO SEWER FLOW LIMITATIONS, 50-YEAR FREQUENCY STORM, 5-YEAR FREQUENCY STORM-SEWER DESIGN
SCALE: 1" = 6 MILES
SANITARY & SHIP CANAL
CHICAGO
CALUMET-SAG CHANNEL
CALUMET RIVER
RIVER
LOCKPORT
JOLIET
COOK COUNTY

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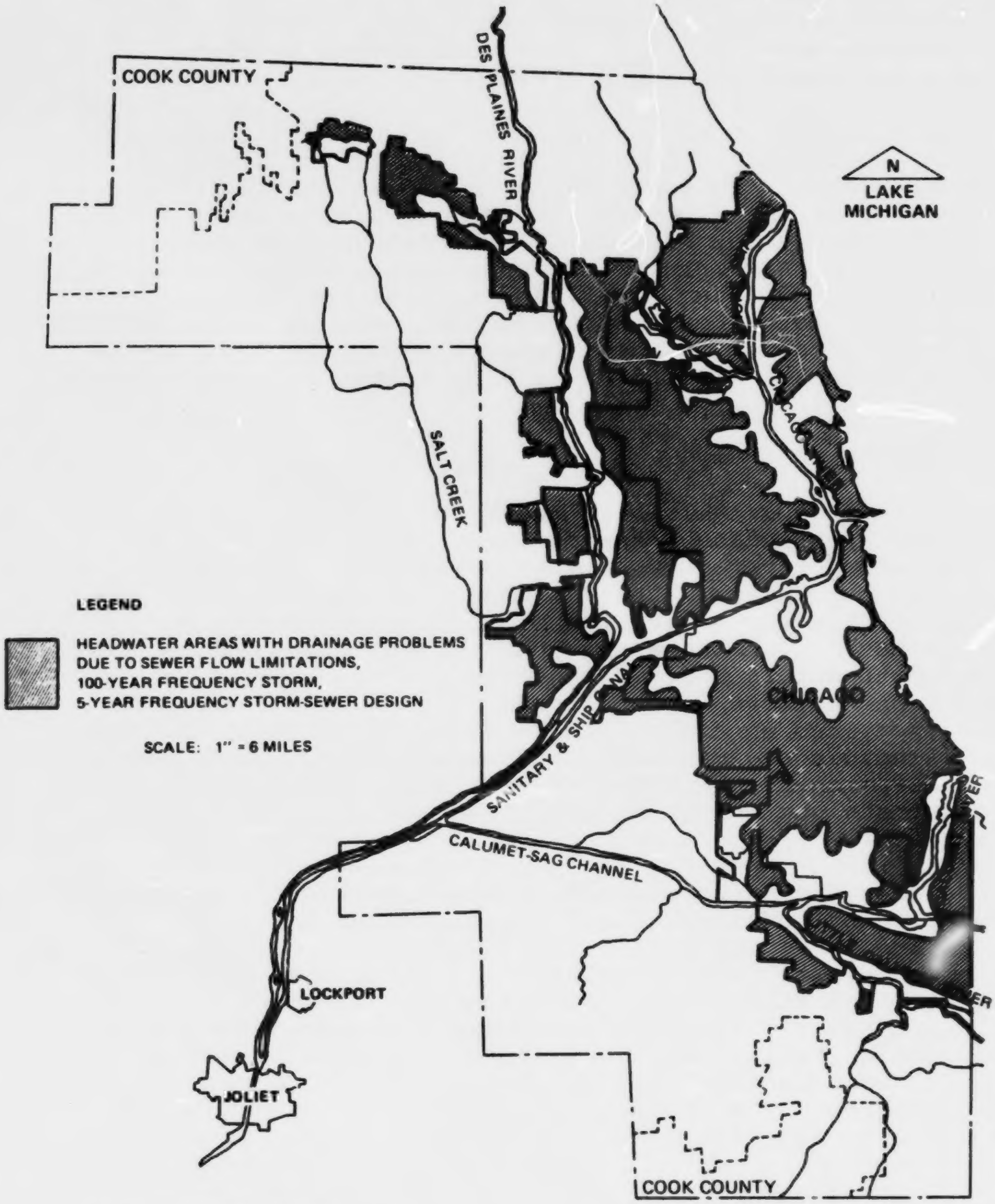
[1] MSDGC Environmental Assessment - Alternative management plans for control of flood and pollution problems due to combined sewer discharges in the general service area of the Metropolitan Sanitary District of Greater Chicago, November 1973, pp. 105-108.

FIGURE II-17
Areas with Drainage
Problems During 100-Year
Storm[1]


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
SALT CREEK
LEGEND
▨ HEADWATER AREAS WITH DRAINAGE PROBLEMS DUE TO SEWER FLOW LIMITATIONS, 100-YEAR FREQUENCY STORM, 5-YEAR FREQUENCY STORM-SEWER DESIGN
SCALE: 1" = 6 MILES
SANITARY & SHIP CANAL
CHICAGO
CALUMET-SAG CHANNEL
LOCKPORT
JOLIET
COOK COUNTY

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[1] MSDGC Environmental Assessment - Alternative management plans for control of flood and pollution problems due to combined sewer discharges in the general service area of the Metropolitan Sanitary District of Greater Chicago, November 1973, pp. 105-108.

2.2.2 Flood-Prone Areas

The lack of topographic relief throughout the Chicago area is a significant factor in overbank flooding. Because high waterway elevations can seriously affect sewer hydraulic capacity, overbank flooding often occurs concomitantly with combined-sewer backup. Areas subject to overbank flooding are shown in Figure II-18.

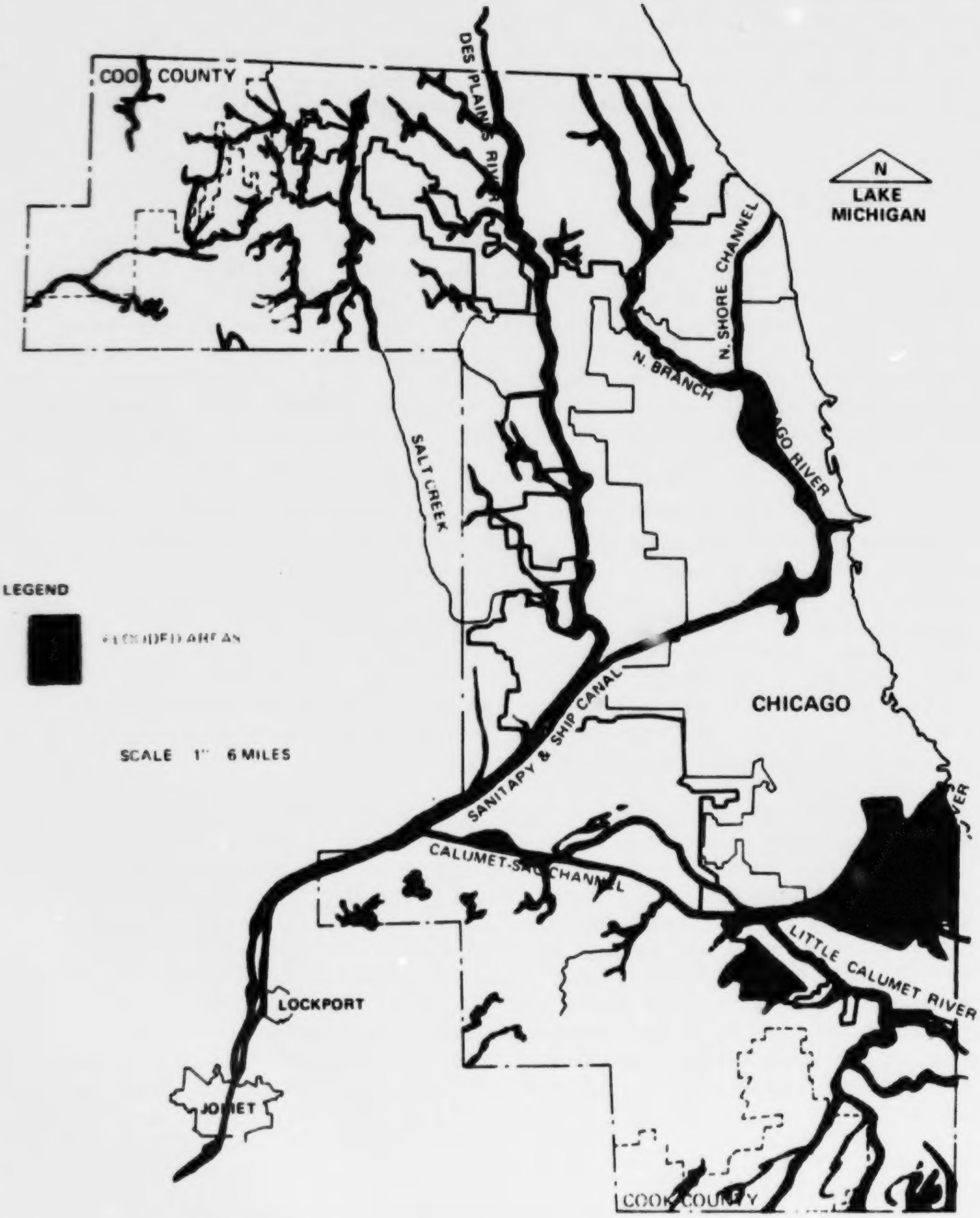
The greatest potential area for overbank flooding lies along the North Branch of the Chicago River and in the Calumet River System. Releases of flood waters to Lake Michigan at Wilmette, at the mouth of the Chicago River, and throughout the Calumet River have largely forestalled overbank flooding along the North Shore Channel, the North and South Branches of the Chicago River, and the Calumet River. Were such releases not allowed, significant overbank and basement flooding would occur in these areas. Along the Des Plaines River, flooding is limited chiefly to forest preserve lands.

2.2.3 Geology

The Chicago area lies on the broad, gently sloping, northwesterly-trending Kankakee Arch. This arch connects the Wisconsin Arch to the northwest with the Cincinnati Arch to the southwest. The Kankakee Arch further is a structural high separating the Michigan Basin from the Illinois Basin. The northeast part of the Chicago area lies on the northeastern side of the arch and the lower Paleozoic formations here dip eastward. The southwestern portion of the area lies on the southwest flank of the arch and the upper Paleozoic sediments dip southwest toward the Illinois Basin. Erosion of the Kankakee Arch has exposed older geologic units along the arch and younger rocks along the flanks.

Beneath the Paleozoic and Mesozoic rocks is the Precambrain basement complex. The Paleozoic/Mesozoic-related sedimentary rocks are some 4,000 feet thick. A number of gentle east-west trending folds are superimposed upon the broad regional structures. Additionally, numerous minor faults and several areas of major faulting have been mapped. The Sandwhich Fault, near Joliet, and the Des Plaines disturbance, near Des Plaines, are major faulting areas in the Chicago region. The sedimentary rocks within the Chicago area are veneered with glacial materials of the Wisconsinan

FIGURE II-18
Areas Subject to Overbank Flooding[1]


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
N. SHORE CHANNEL
N. BRANCH
AGO RIVER
SALT CREEK
LEGEND
FLOODED AREAS
SCALE 1" 6 MILES
CHICAGO
SANITAPY & SHIP CANAL
CALUMET-SAG CHANNEL
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY

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[1] MSDGC Environmental Assessment - Alternative management plans for control of flood and pollution problems due to combined sewer discharges in the general service area of the Metropolitan Sanitary District of Greater Chicago, November 1973, pg. 101.

stage which were deposited during the four glacial stages comprising the Pleistocene series. They were deposited in generally shallow seas that advanced and retreated across the interior of North America some 300 to 500 million years ago. Occasional uplifts caused previously deposited sediments to be raised above sea level, exposed to erosion, and then buried under deposits of readvancing seas. The effects of erosion results in stratigraphic breaks, or unconformities in the sedimentary rock sequence.

(1) Geologic History

The oldest rocks in the region are of Precambrian age, collectively known as the basement complex, and can be found in several northern states areas. These rocks are composed of metamorphic and igneous materials which were subjected to complex tectonic and erosional processes prior to the deposition of the oldest Paleozoic sediments. A sharp unconformity marks the division between these Precambrian rocks and the lowest Cambrian rocks.

In the immediate Chicago area, the Precambrian/Cambrian unconformity is 3,000 to 5,000 feet below the surface. The Cambrian rock is composed of marine deposits comprising both near-shore and deeper water sediments. The rocks are predominately sandstones in the lower portion and mixed sandstones, siltstones, dolomites, and sandy dolomites in the upper portion. These sediments represent a sea that covered the entire region. Only a minor unconformity separates the Cambrian and lower Ordovician rocks.

After the deposition of the lower Ordovician, erosion occurred and the middle Ordovician lies directly on Cambrian strata or truncates lower Ordovician rocks. The unconformity is irregular and is locally marked by sandstone-filled valleys and sinkholes. This unconformity is exposed in areas to the west, south, and north but lies 300 to 1,000 feet deep within the Chicago region. The erosion in lower Ordovician time may represent an earlier movement along the Kankakee Arch.[1] The Ordovician sediments include sandstone, shale, dolomite, and limestone, and are considered to be of marine origin.

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[1] Willman, H.B., "Summary of the Geology of the Chicago Area," Illinois State Geological Survey, Circular 460, 1971.

The end of Ordovician time was marked by uplift, and resulted in deep valleys being cut in the uppermost Ordovician rocks. In places these valleys are 150 feet deep. The Silurian sediments are indicative of shallow interior seas. The rocks are almost all dolomite, and highly fossiliferous reef deposits mark the Niagaran series. The Silurian rocks form much of the bedrock surface in the Chicago area as shown in Figure II-19.

Within the immediate region of Chicago, a marked unconformity occurs at the base of the middle Devonian. This unconformity coincides with the tectonic uplift in the Appalachians. The Middle Devonian truncates units as low as the middle Silurian, although lower Devonian rocks are present and undisturbed to the south in the center of the Illinois Basin. Devonian rocks are found in the Chicago area beneath Lake Michigan and possibly in some crevices in the eroded surfaces of the Silurian Racine formation, as well as in the Des Plaines disturbance. The relations of the Devonian to older units appears to be the result of uplift along the Kankakee Arch.[1] The Devonian sediments consist of limestone and shales with occasional sandstones.

Mississippian sediments are found around the edges of the Michigan and Illinois Basin and the Ozark Dome, northeast and southwest, respectively, of the Chicago area. These rocks are predominately limestone and cherty (flintlike) limestone with some shales, dolomite, and sandstone. Within the Chicago area, the Mississippian is found as shale and cherty limestone in the Des Plaines fault zone.

Pennsylvanian rocks are found south, west, and east of Chicago and may be tentatively present in the Des Plaines structure. A major unconformity marks early Pennsylvanian time, resulting from regional uplift and warping of the Kankakee Arch. Depression of the Illinois Basin in mid to late Pennsylvanian resulted in deposition of upper Pennsylvania sediments on the truncated older rock units. The Pennsylvanian rocks are predominately shales and sandstone with clay and coal measures and occur in cyclothams.

The Chicago area was uplifted and warped during the major tectonic movements in the Applachians at

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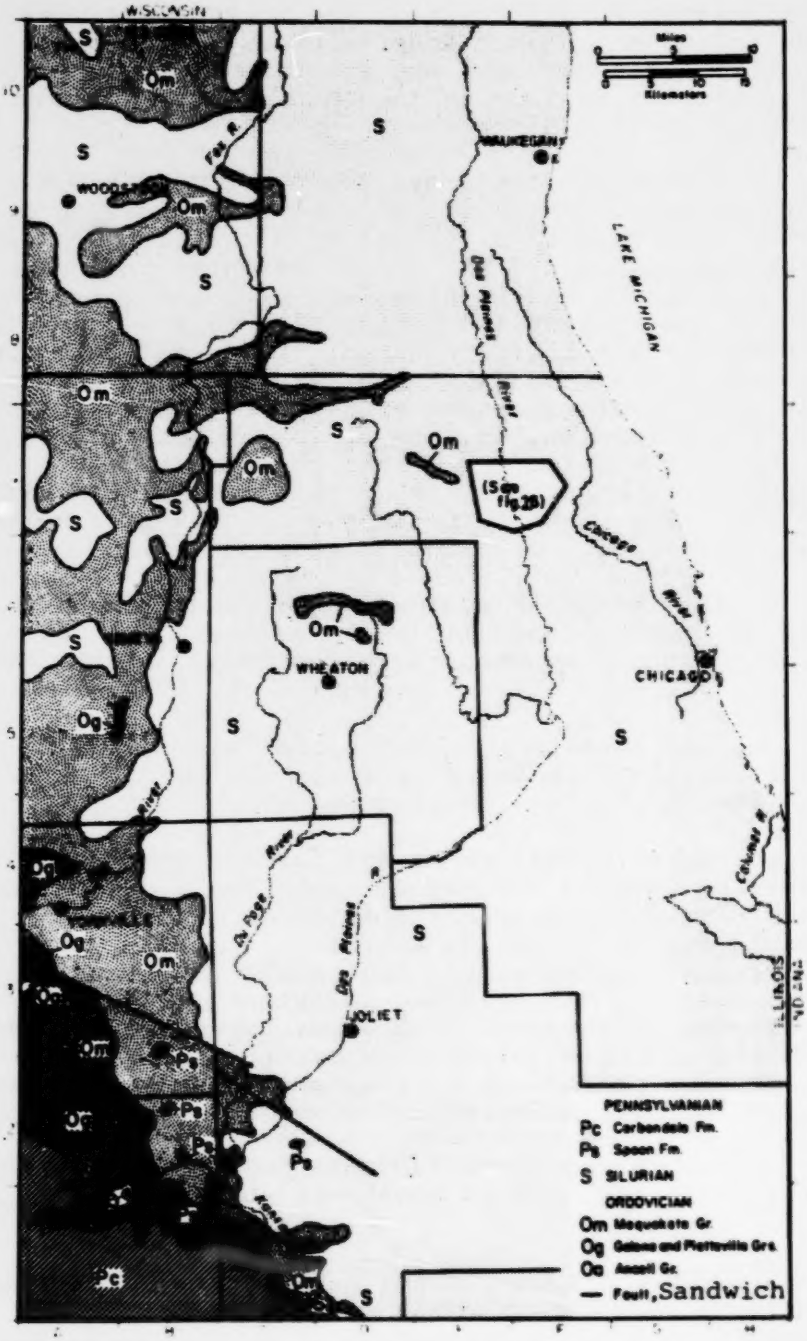
[1] Willman, H.B., "Summary of the Geology of the Chicago Area," Illinois State Geological Survey, Circular 460, 1971.

FIGURE II-19
Bedrock Surface Geology[1]

GEOLOGY OF THE CHICAGO AREA


WISCONSIN
Miles
0 5 10
0 5 10 15
Kilometers
S
Om
Fox R.
WOODSTOCK
WAUKEGAN
Des Plaines River
LAKE MICHIGAN
(See fig 28)
Chicago River
CHICAGO
WHEATON
Og
Du Page River
Des Plaines R.
JOLIET
Calumet R.
ILLINOIS
INDIANA
Ps
Pc
PENNSYLVANIAN
Pc Carbondale Fm.
Ps Spoon Fm.
S SILURIAN
ORDOVICIAN
Om Maquoketa Gr.
Og Galena and Platteville Grs.
Oa Ancell Gr.
— Fault, Sandwich

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[1] Willman, H.G., "Summary of the Geology of the Chicago Area," Illinois State Geological Survey, Circular 460, 1971.

the end of the Paleozoic.[1] Renewed uplift along the Kankakee Arch caused the erosion of Pennsylvanian sediments from the Chicago area. Although Cretaceous sediments are found west and south of Chicago, there is no evidence for their deposition within the area.

A major unconformity occurs between the Paleozoic and Quaternary systems. In the Chicago region, the glacial deposits of Pleistocene age rest directly on the erosional surface of Pennsylvanian and older rocks. During the Wisconsinan stage, the Chicago area was buried under several thousand feet of glacial ice that spread over the region from the northeast. These glaciers were part of the Lake Michigan lobe (rounded division or projection) but may have included marginal portions of the Saginaw and Green Bay lobes.

The Wisconsinan glaciation eroded the Chicago area so intensely that no deposits of earlier glaciers have been found.[2] Deposits from the Illinoian glaciation which preceded the Wisconsinan, may remain in some of the bedrock valleys in the Chicago region. Deposits of the Kansan stage are present southwest of Chicago and it is probable that the northern edge of a Kansan glacier from the northeast also may have covered part of the region. There is no evidence that the earliest Pleistocene glaciers of the Nebraskan stage covered the Chicago area.

Most of glacial drift in the Chicago area was deposited during Woodfordian time. This was a time of maximum Wisconsinan glaciation and extended from 22,000 to 12,500 years ago. At its maximum, the Woodfordian glacier extended westward nearly to the Mississippi River, southwestward to Peoria, and southward to its contact with the Erie lobe, which advanced from the east. At the maximum, the Chicago area was buried by 3,000 to 5,000 feet of ice. As the glacier retreated northward, the Lake Michigan Basin filled with melt water which formed Lake Chicago.[3]

Readvance of the glaciers in northern Michigan during Valderan time caused a rise in Lake Chicago level. Subsequently, the Valderan glaciers advanced on the land as far as Milwaukee and even further south in the central part of Lake Chicago. Valderan time is marked by lacustrine, fluvial, and aeolian deposits in the Chicago area.

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[1] Willman, H.B., "Summary of the Geology of the Chicago Area," Illinois State Geological Survey, Circular 460, 1971.

[2] Ibid.

[3] Ibid.

The post-glacial stage has been called the Holocene and, according to some, includes the present or recent geologic processes acting on the landscape. The Holocene is considered to have commenced some 7,000 years ago and in the Chicago area is marked by soil formation, peat, stream, and Lake deposits. Additionally, such man-made features as lake fill, land fill, and strip mine wastes, may be considered as Holocene deposits.

The present topography or physiography of the Chicago area owes its origin to the glacial and post-glacial processes including stream erosion, wind blown deposits, and wind erosion.

(2) Physiography

The major features of the Chicago area are in a youthful stage of geomorphic development. Depositional features include substantially unaltered moraines (glacial deposits), outwash plains, valley trains, filled lake basins, river flood plains, and sand dunes. Erosional features include glacial flood-water sluiceways, glacial lake wave cut cliffs, and numerous small stream valleys. Total relief is on the order of 590 feet.

The Chicago area is in the Central Lowlands Province, a broad, relatively low glaciated area extending from the Applachians to the Great Plains along its east-west axis and from the Superio uplands to the Interior low plateaus and Ozark plateaus along its north-south axis. The boundary between two major subdivisions of the central lowlands, the Great lakes section, and the Till Plains section lies just to the west of Cook County.

The Great Lakes section includes the younger glacial drift surrounding the Great Lakes and is characterized by permanent rough-surfaces moraines and many lakes. Within the Chicago area the Great Lakes section has two subdivisions, the Wheaton Morainal Country and the Chicago Lake Plain. The former contains continental glaciation physiographic features including glacial deposits, hill and hollow topography, short ridges and numerous lakes. The Chicago Lake Plain comprises the former bottom of glacial Lake Chicago and is relatively flat and uneroded by modern streams.

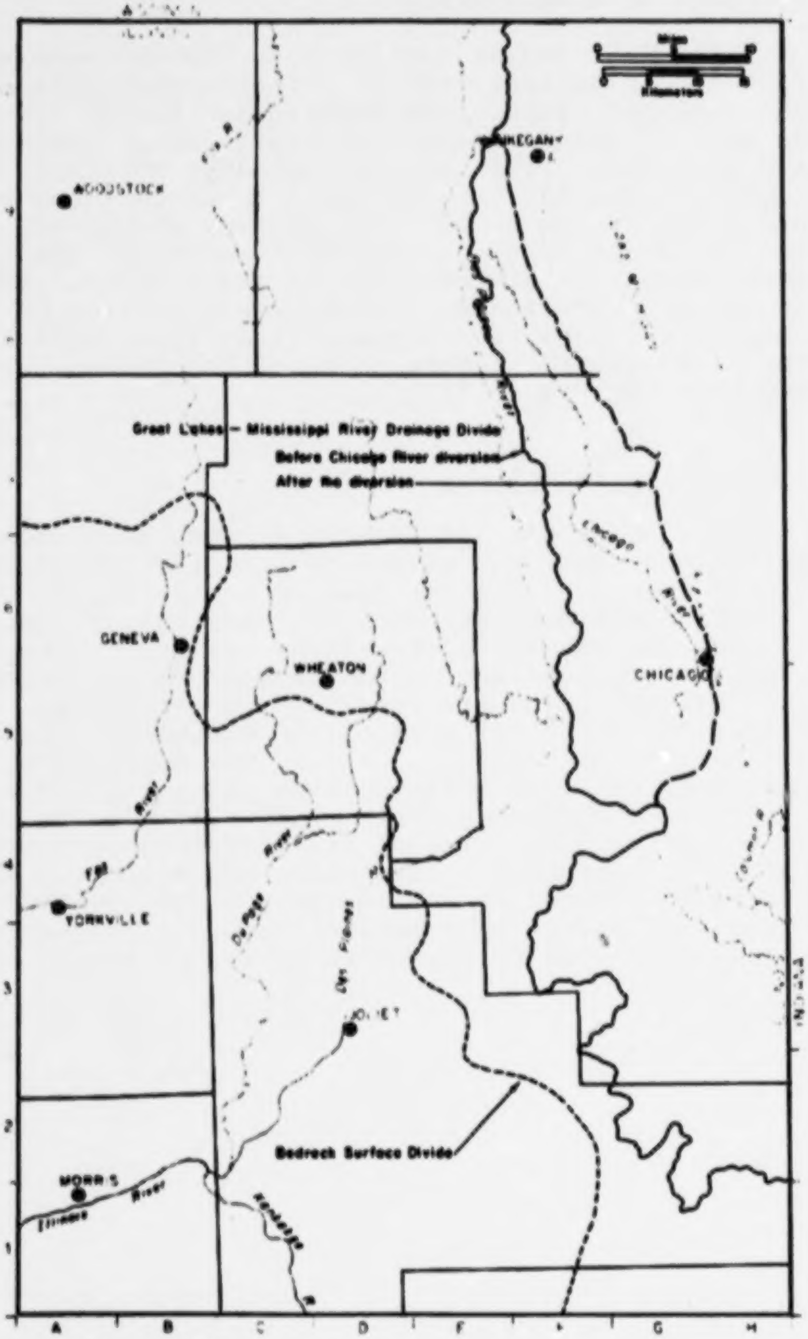
The Till Plains section also has two subdivisions in the Chicago area, the Bloomington Ridges Plain and the Kankakee Plain. The Bloomington Ridged Plain is an area of older Wisconsinan drift and is less rugged and with fewer lakes than the Wheaton Morainal Country. The scarcity of Lakes is in part due to the older age of the drift. The gentler slopes and lower relief is due to the slower melting of the ice and less stagnation at the front of the glacier. The Kankakee Plain lies in the southwest portion of the Chicago area and is a comparatively flat surface. The physiographic subdivisions of the Chicago area are shown in Figure II-20.

(3) Site Stratigraphy

The uppermost 500 feet of strata, particularly in the dolomites and shales between the top of the Racine formation and the base of the Brainard formation are most relevant to the proposed construction of the tunnel and reservoir systems. The glacial deposits are relevant to the drop shaft construction and, partially, to the reservoir containments. The formations above the base of the Maquoketa group's Brainard formation are a part of the Quartenary, Silurian, and Ordovician systems and a brief description highlighting their major features are presented below. The general stratigraphic relations of the rock formations below this group have been described in a broad manner in the previous section on geologic history. The general geologic column for the Chicago area is presented in Figure II-21.

FIGURE II-20
Physiographic Divisions in
the Chicago Area[1]

GEOLOGY OF THE CHICAGO AREA


WOODSTOCK
WAUKEGAN
Miles
Kilometers
Great Lakes – Mississippi River Drainage Divide
Before Chicago River diversion
After the diversion
Chicago River
GENEVA
WHEATON
CHICAGO
Fox River
YORKVILLE
Du Page River
Des Plaines
JOLIET
Bedrock Surface Divide
MORRIS
Illinois River
Kankakee
A
B
C
D
E
F
G
H
1
2
3
4
5
6

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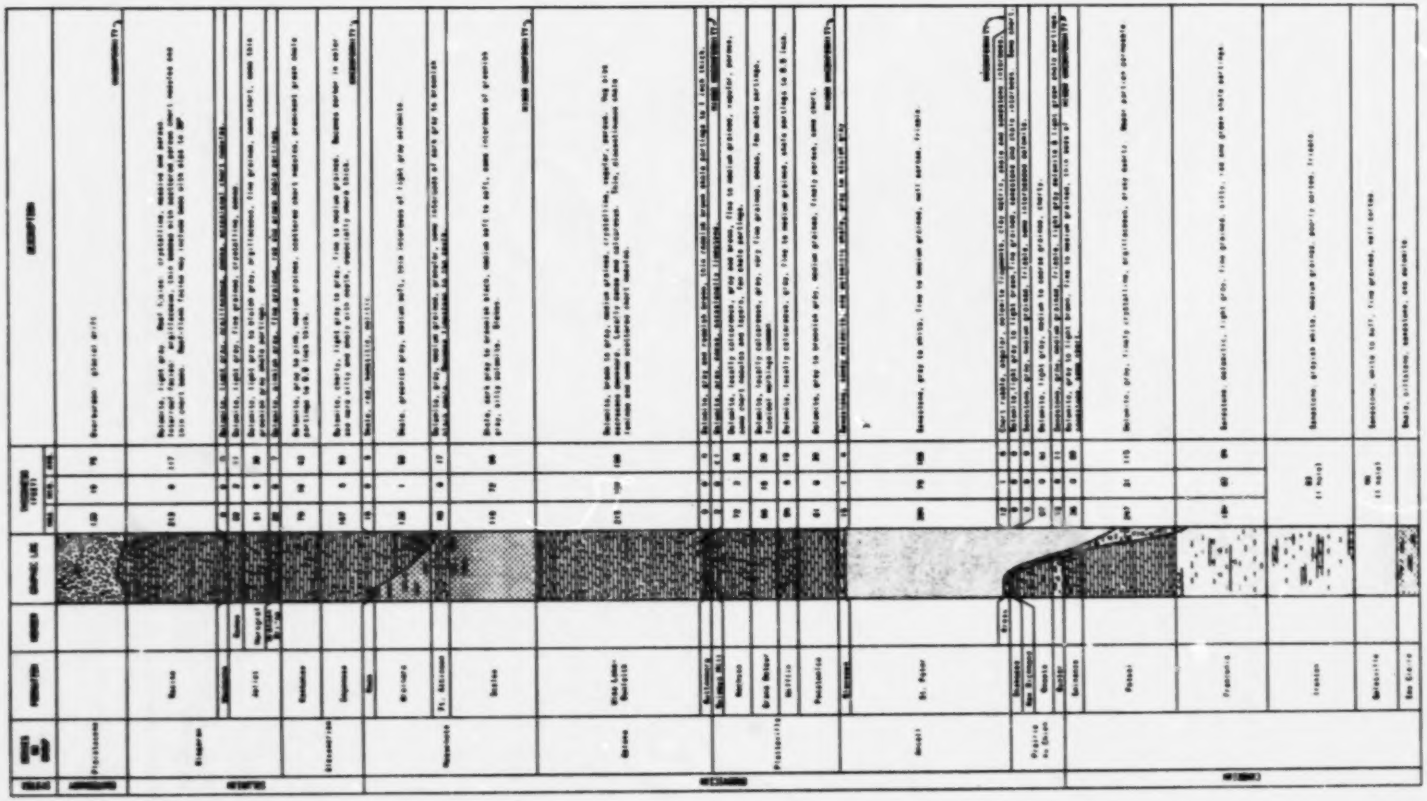
1 Willman, 1971.

FIGURE II-21
Generalized Stratigraphic Column
For the Chicago Area[1]


DESCRIPTION
Overburden: glacial drift
Pleistocene
Niagaran
Racine
Joliet
Alexandrian
Kankakee
Maquoketa
Brainard
Ft. Atkinson
Scales
Galena
Wise Lake-Dunleith
Platteville
Ancell
St. Peter
Sandstone, gray to white, fine to medium grained, well sorted, friable.
Prairie du Chien
Potosi
Franconia
Ironton
Galesville
Eau Claire
Shale, siltstone, sandstone, and dolomite

[illegible]

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[1] Harza Engineering Company, "Geology and Water Supply," Technical Report, Part 4, 1972.

1. Quartenary

Underlying the surficial soil and artificial fill material in the project area are the Pleistocene Series of deposits. These consist of a variety of materials transported by, or directly related to, the continental glaciers that covered the Chicago area. These deposits, designated as glacial drift, range in thickness locally from 0 to over 200 feet. The depth range of the glacial deposits at most places is perhaps 60 to 90 feet.

2. Silurian

The Racine dolomite, the youngest most variable and topographically highest of the Silurian system consists of dolomite with some chert and shale. The thickness of the formation is 0 to 20 feet, north of the O'Hare Airport area. Towards the south and east, the thickness reaches 70 feet in Wilmette, 213 feet at Roosevelt Road and Lake Shore Drive, and a maximum of 291 feet in the Lake Calumet area. The overall thickness throughout the Chicago area ranges from 100 to 175 feet.

The Joliet formation is the next underlying formation in the Silurian system and consists of three members: the Romeo, the Markgraf, and the Brandon Bridge. The Romeo member is a persistent thin, uniform, light gray, very dense, fine grained dolomite, generally about 9 to 17 feet thick, that underlies the Racine dolomite and grades downward into the Markgraf member. The Markgraf member, however, is a widespread, distinctively light bluish gray dolomitic unit with an average thickness of 31 feet. The member underlies the Romeo member with a sharp contact and minimum thickness is 9 feet with a maximum of 51 feet. The Brandon Bridge member is absent in most of the Chicago area. This member is found chiefly in the northwestern portion of the area, especially in the Des Plaines Valley.

Below the Joliet formation in the Kankakee the characteristic features of the dolomite in this formation are: wavy beds of fine to medium grained gray, locally pink, dolomite layers, 1 to 3 inches thick. The Kankakee dolomite as found throughout the Chicago area, usually has a thickness of 35 to 45 feet, but may vary somewhat from these figures. The contact with the Edgewood formation below is conformable.

The Edgewood formation is the lowermost formation in the Silurian System. The material in this formation is a light gray, fine to medium grained, argillaceous, cherty dolomite. It includes a porous upper zone and a middle and lower zone that contain numerous shale partings. Deposited unconformably on the irregularly channeled, eroded surface of the Ordovician Maquoketa Group (generally the Brainard Shale), the Edgewood thickens from averages of approximately 20 feet in interchannel areas to over 100 feet in depressions within the Brainard.

3. Ordovician

The Neda formation, the uppermost formation of the Ordovician system is an iron oxide-bearing, brick red shale, 0 to 15 feet thick (5 feet average) of restricted distribution. In general, the formation is found in the same places as the Brandon Bridge Formation. Much of the Neda was probably removed by pre-Edgewood erosion.

The Brainard formation consists of a material that is a dark green-gray, thin bedded fossiliferous, silty claystone to shale, and interbedded dolomite.

As a result of pre-Edgewood erosion, as described above, the Brainard Shale as observed has acquired a variable thickness of from 1 to 136 feet depending on the configuration of the Brainard-Edgewood unconformity. In many holes, thickness of the formation is less than 50 feet. In the Calumet area, the Brainard is absent at places.

(4) Unconformities

Contacts between adjacent rock strata which show that deposition was interrupted and that beds have been removed by erosion are unconformities. Most of the rock units in the Chicago area show conformable relations with the beds above and below. This indicates that there was no major interruption in deposition within or between these formations.

Major unconformities within the general Chicago region occur at the base of the Midle Ordovician, the Silurian (top of the Maquoketa), the Middle Devonian, the Pennsylvanian, the Cretaceous, and the Pleistocene (bedrock surface) systems. Of these major unconformities, only two, the bedrock surface and Maquoketa unconformities, lie within the stratigraphic or geographic boundaries of the project. These two unconformities are discussed below while the other unconformities have been discussed in the section on geologic history.

1. Bedrock Surface Unconformity

The surface of bedrock is an erosional surface. Over most of the Chicago area the Niagaran Racine dolomite forms the bedrock surface. Both older and younger rocks are at the top of rock within the disturbed zone of the Des Plaines complex. To the northwest of this faulted area, the Joliet formation, Kankakee, and Edgewood dolomites and the Maquoketa shale are locally at the bedrock surface.

Erosion during and following the uplift of the Kankakee Arch contributed to the exposure of the present rock surface. Glacial erosion, however, appears to have been a major factor in shaping and lowering the rock surface to its present form. Topography on the bedrock surface shows a rolling plain cut by steep eastward grading valleys over 100 feet deep. Evidence of previous geologic structure caused by folding and faulting has been modified by the preglacial and glacial erosion. Glacial drift has unconformably filled in depressions in the bedrock surface so that present day drainage patterns are almost entirely independent of preglacial drainage.

2. Top of Maquoketa Group Unconformity

The top of the Maquoketa group is an erosional surface. Generally eastward grading valleys up to 150 feet deep have been carved into the Maquoketa surface. The configuration of the surface appears to be independent of that of the underlying Galena surface. In some areas, a structural high on the top of the Galena may be reflected in a corresponding topographic high on the top of the Maquoketa, as in the southern portion of the tunnel between Western and Kedzie Avenues (Figure II-22). The effect of the high Maquoketa top in this hole and others appears, however, to be reflected upward in sedimentary beds (e.g., Edgewood, Kankakee, and Joliet formations) deposited at a later time.

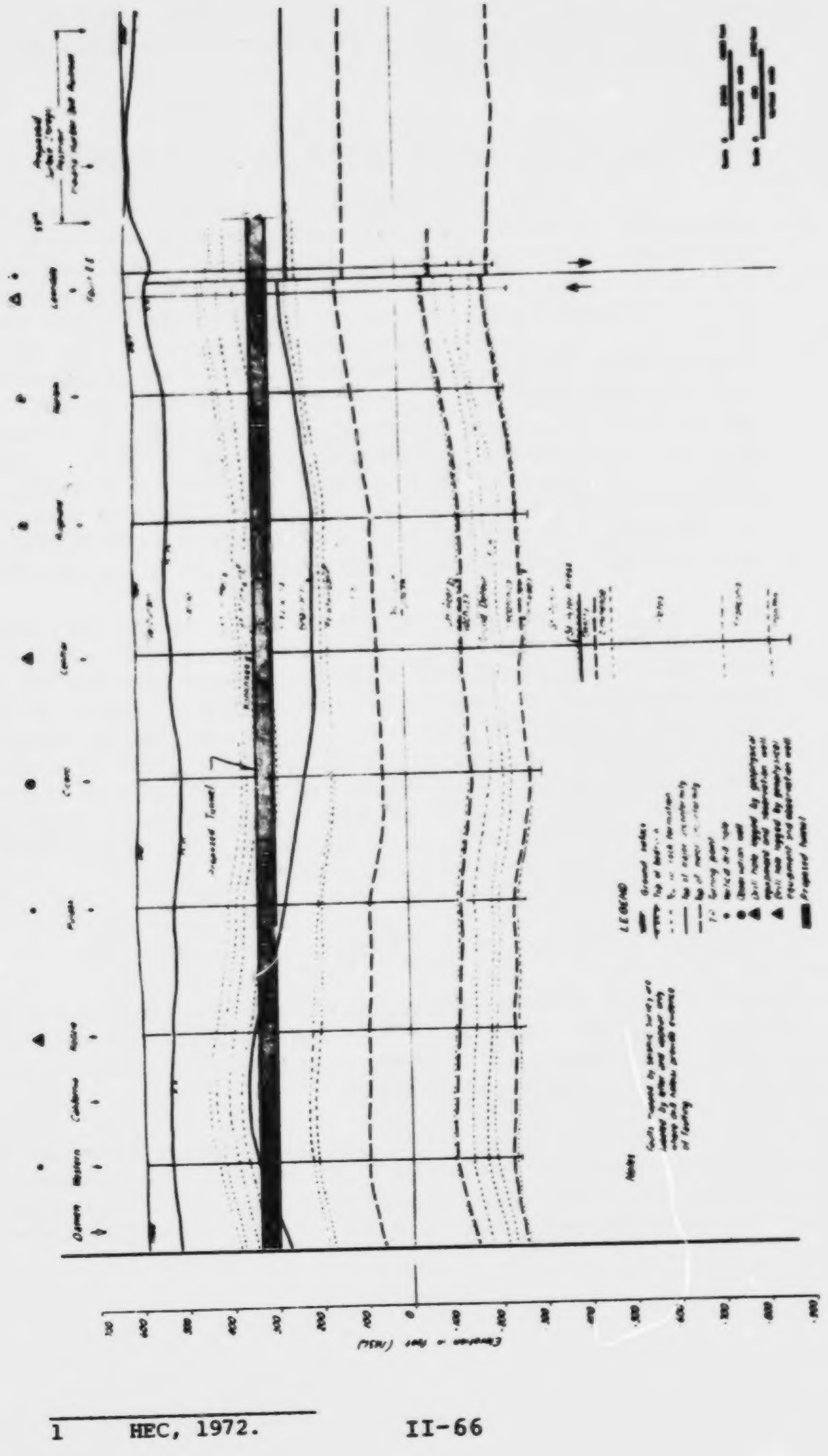
Erosion has removed the Neda shale at the top of the Maquoketa group over most of the area. In the drilling program, Neda was encountered only in the northwestern part of the project area, along the Des Plaines River and along the North Branch of the Chicago River. Erosion has also thinned the Brainard shale in all holes where the Neda is absent. In portions of the Lake Calumet area, erosion has cut entirely through the Brainard shale into the Fort Atkinson dolomite.

(5) Folds

Folding of the bedrock units in the Chicago area is represented by very gentle folds with eastwest trends which are superimposed on the regional southeasterly dip of 10 to 15 feet per mile.

The folds are gentle structures which develop relief of 200 feet, or generally less, over a extent of several miles. Structure surface slopes, which may be taken to approximate the dip of the strata involved

FIGURE II-22
Geologic Section
59th Street to Damen Avenue
Mainstream System[1]



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[1] HEC, 1972.

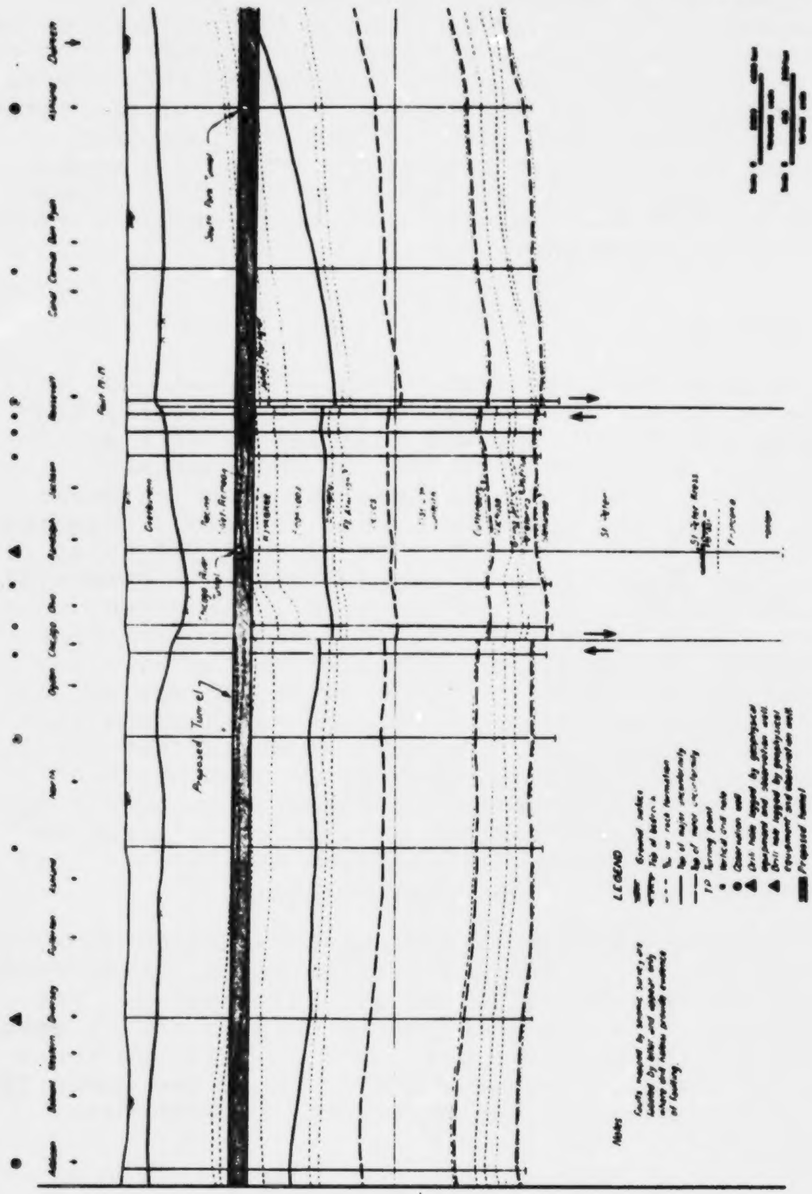
in the folding, are found locally to approach 100 feet per mile. The fold axes in the Galena trend east-west and appear to be generally conformable with deeper structures. The gently undulating fold structures can be observed in the geologic sections prepared from the core borings which have been included in this report as Figures II-22 through II-26 . The dip of the strata shown on the sections, even if the sections were constructed true to scale rather than with 20:1 exaggeration as drawn, would not represent true dips at many places because the geologic section lines often cross the fold axes obliquely.

(6) Joints

Data on the orientation dip and spacing of joints in the Silurian strata were obtained primarily from the mapping of outcrops and quarries as well as tunnels, especially druing construction of the Southwest Intercepting Sewer 13A, Calumet Intercepting Sewer 18-E, Ext. A, and Lawrence Avenue Tunnels (including the Harding Avenue Tunnel). Vertical drill holes of relatively small diameter rarely intersect essentially vertical joints. Such joints were intersected, however, in some drill holes and were followed intermittently throughout considerable lengths of the holes. The orientation of the most highly developed set of joints trends northeast ranging from north-50-degrees-east to north-60-degrees-east. Another important set trends northwest, from north-25-degrees west to north-65 degrees west. Joint data for formations underlying the Silurian strata are not available but could be gathered from outcrops remote from the Chicago area or from mines such as those near Galena.

The tunnels listed above were excavated in dolomite strata of the Racine, Joliet, and Kankakee formations, all belonging to the Silurian system. The Racine formation was encountered only in the Calumet Tunnel and the Kankakee was found only in the South-West and Lawrence Avenue Tunnels. Only the upper five feet of the Kankakee was penetrated in each case.

FIGURE II-23
Geologic Section
Damen Avenue to Addison Street
Mainstream System[1]


Proposed Tunnel
LEGEND
Notes

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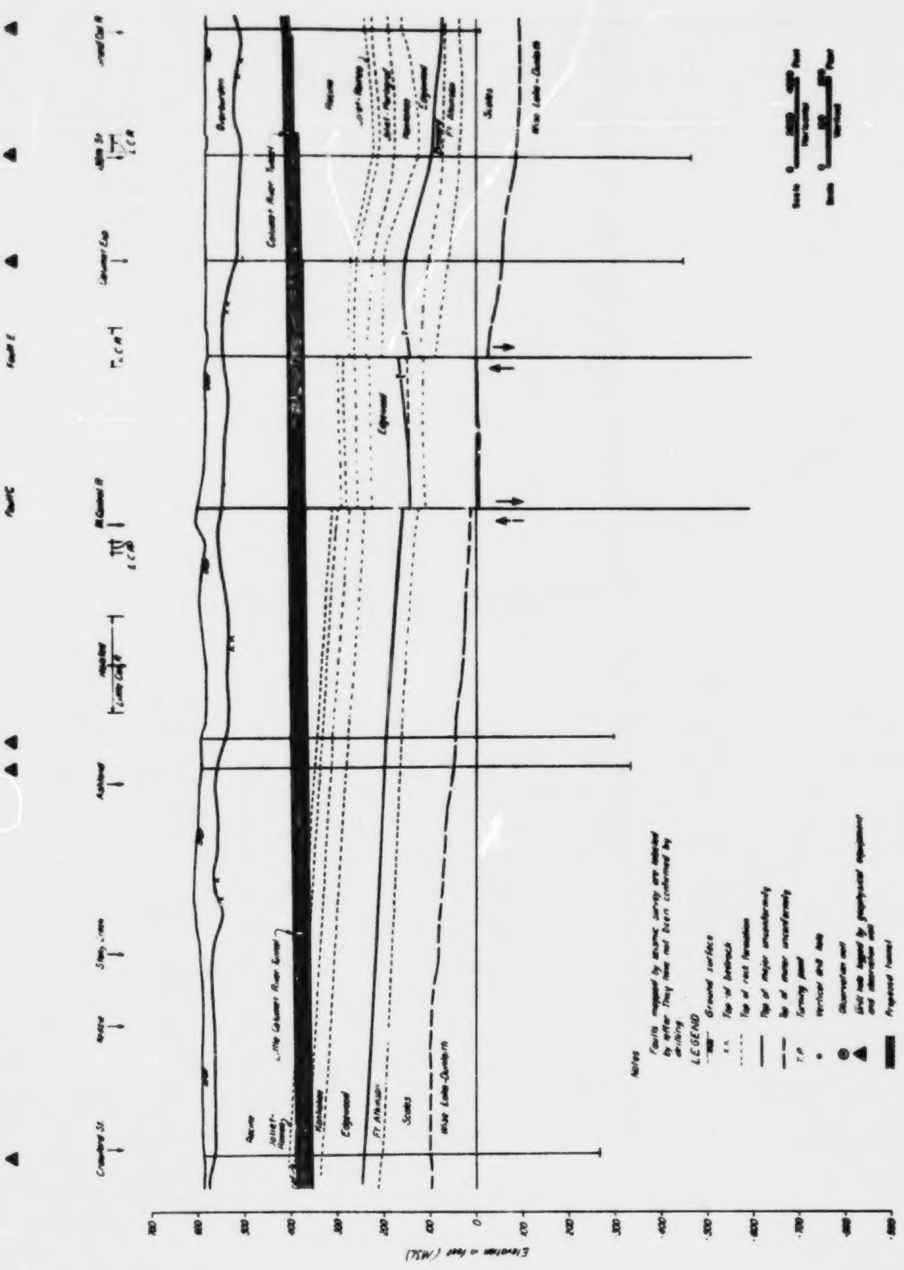
[1] HEC, 1972.

FIGURE II-24
Geologic Section Crawford St.
to Grand Calumet River
Calumet System[1]


Crawford St.
Racine
Joliet-Kankakee
Maquoketa
Edgewood
Ft. Atkinson
Scales
Wise Lake-Dunleith
Little Calumet River Tunnel
Calumet River Tunnel
Ashland
Notes
LEGEND
Ground surface
Top of bedrock
Top of rock formation
Top of major unconformity
Top of minor unconformity
Turning point
Observation well
Proposed tunnel
Elevation in feet (MSL)

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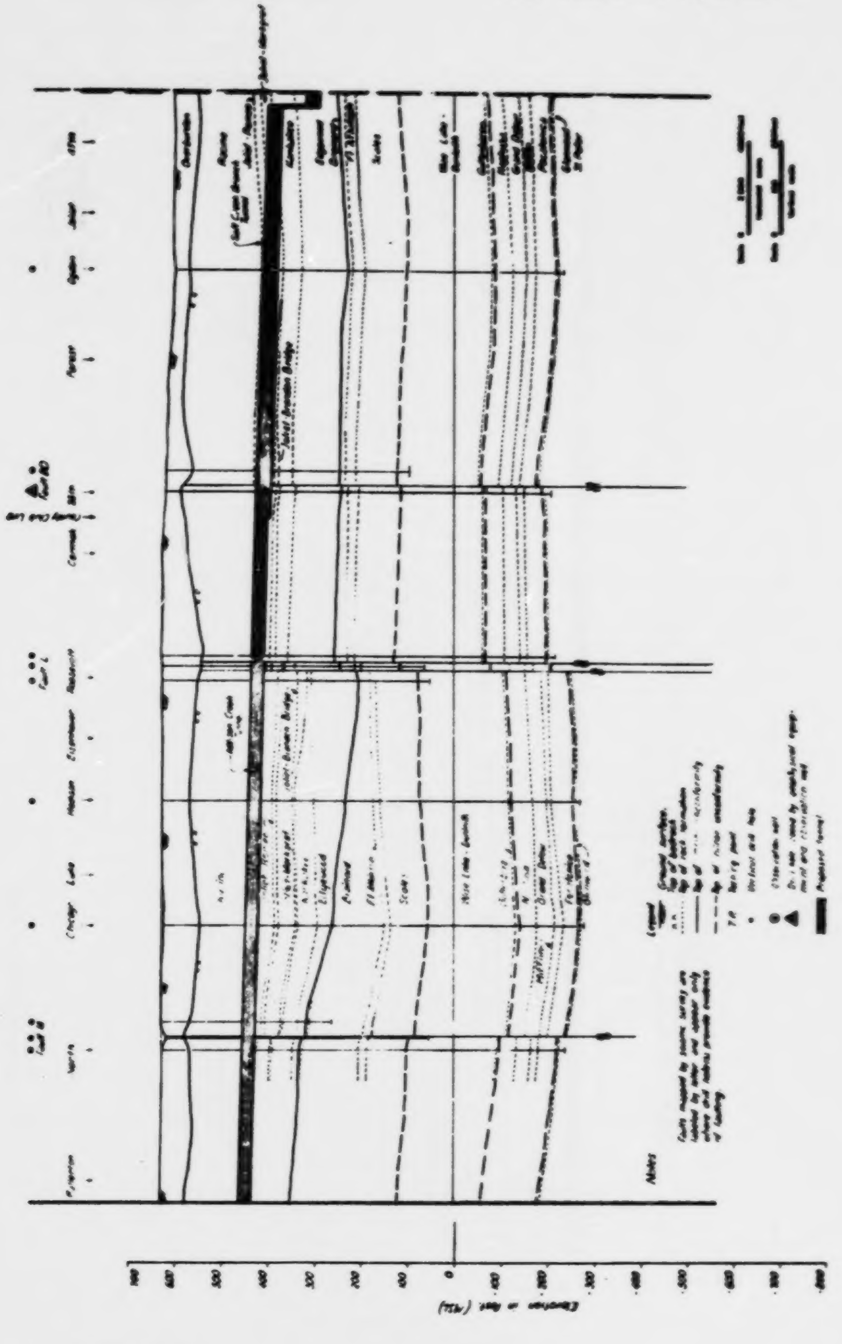
[1] HEC, 1972.

FIGURE II-25
Geologic Section 47th St. to Fullerton Ave. Lower Des Plaines System[1]



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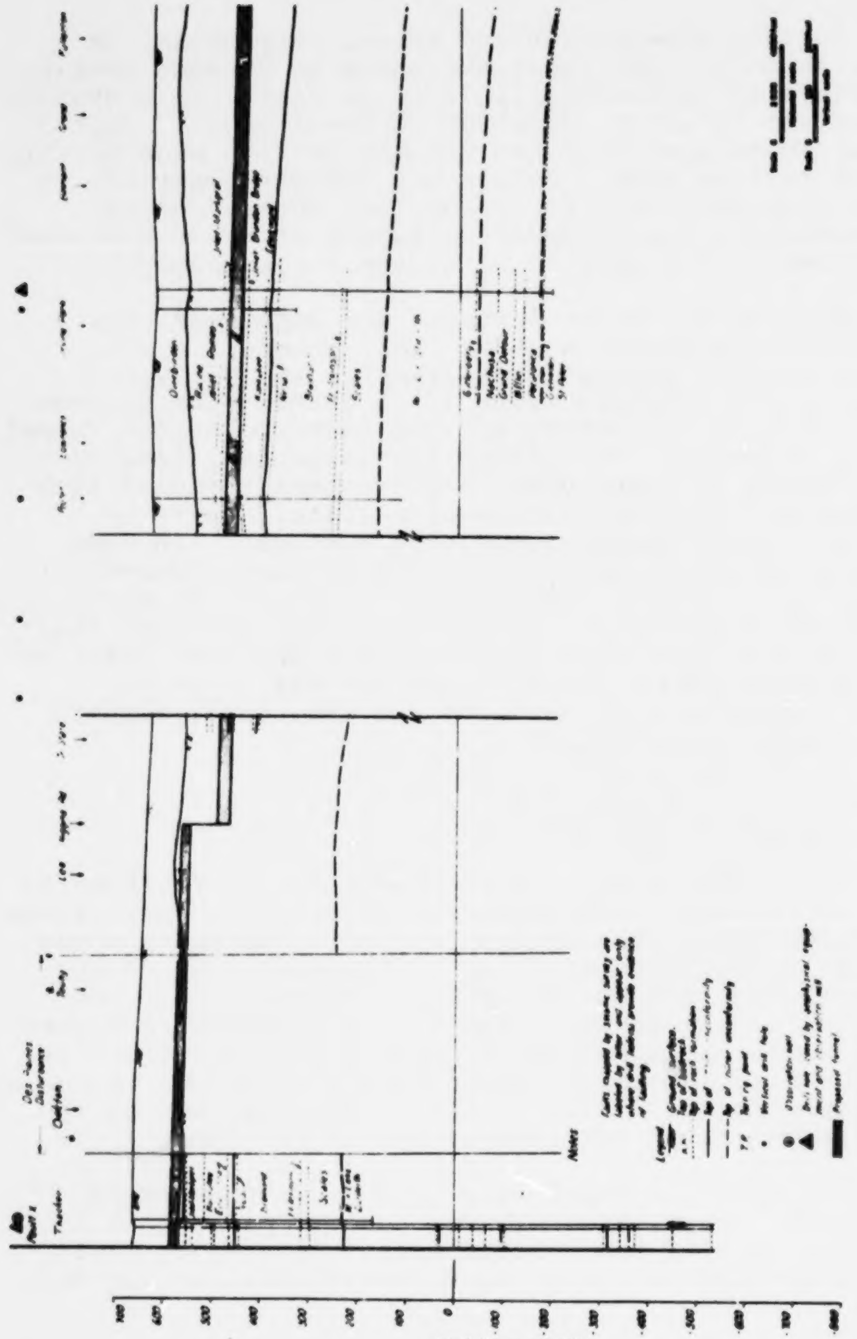
[1] HEC, 1972.

FIGURE II-26
Geologic Section Fullerton Ave. to Thacker Lower Des Plaines System[1]



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[1] HEC, 1972.

Data on jointing from tunnel exploration, therefore, was limited essentially to the Joliet formation and to strata a few feet above and below the formation.

Surface observation and tunnel mapping in the Silurian formations excavated shows an average spacing of joints of approximately 30 to 40 feet. This spacing is subject to great variation in local areas. Joints appear to be open near the bedrock surface with depths of 100 feet or more. Joints are thought generally to close with depth but exceptions may occur. Joint openness as a near-bedrock-surface phenomenon has been discussed in the section on Racine stratigraphy.

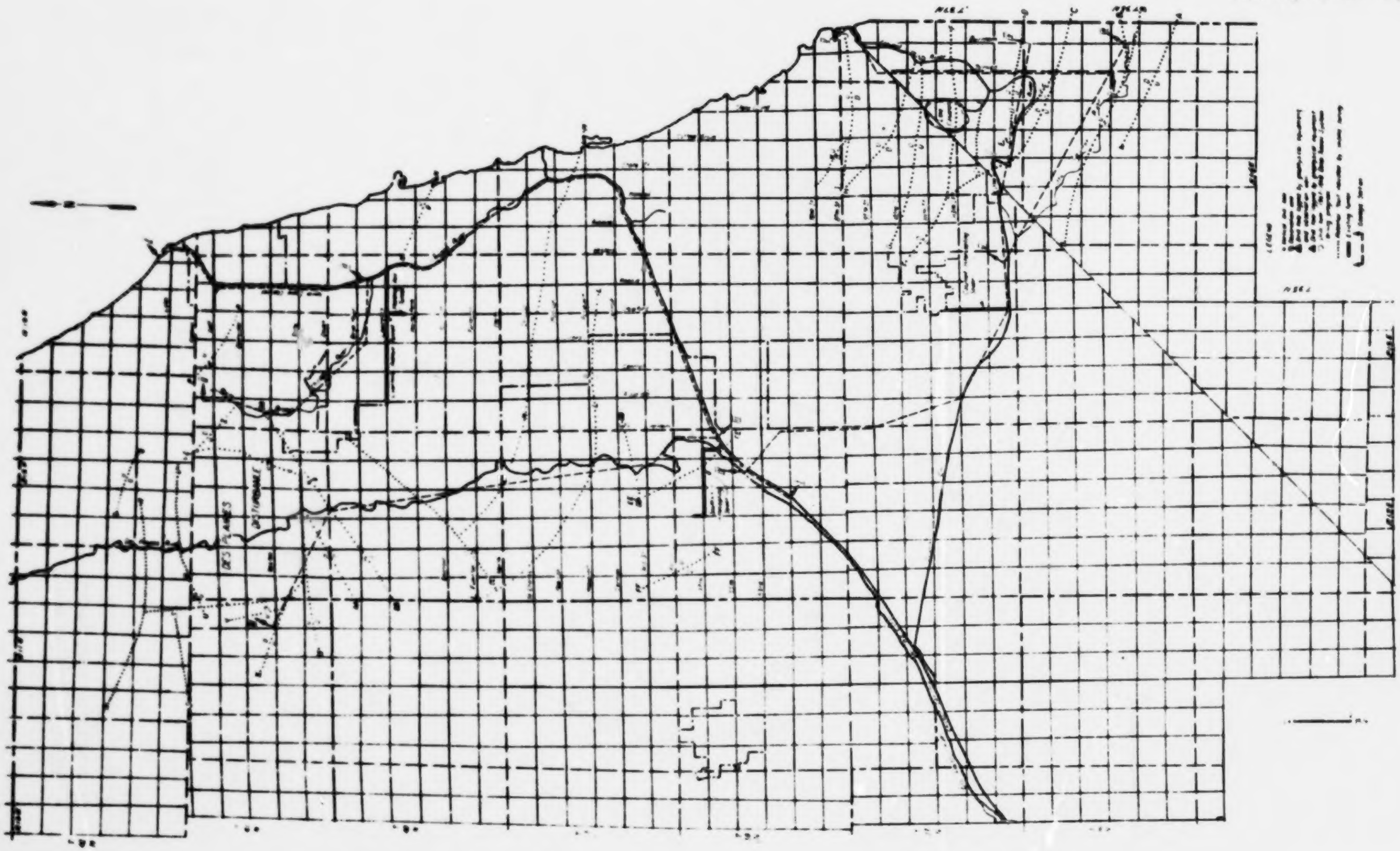
Most of the joint surfaces are separated from a hairline to a fraction of an inch, however, a few obtain greater widths. For example, the Southwest Tunnel has a fracture width of 12 inches, the Calumet tunnel one of 24 inches, and the Lawrence Avenue Tunnel one of 6 inches. The joints are variably filled with grey, black or green clay, and frequent residual rock fragments. Crystallization of calcite, quartz or pyrite is also found along joint surfaces. In some areas solutioning along joint plains has produced horizontal fluting or a "washboard" structure, in which clay fills the pockets. Up to 100-foot wide sections filled with clay have been reported near the Lake Shaft of the Chicago Avenue Tunnel. Seepage was noted as being common in such sections and structural support was usually required.

(7) Faults

Two areas of major disturbance due to faulting as well as numerous individual faults or minor fault zones are known within the Chicago region. The major zones are the Sandwich Fault lying to the southwest of the project area, and the Des Plaines disturbance. The location of the Sandwich Fault zone is shown in Figure II-19 while the location of the Des Plaines structure and the distribution of other faults are shown in the areal map presented as Figure II-27 . A detailed map of the Des Plaines fault structure is given in Figure II-28 .

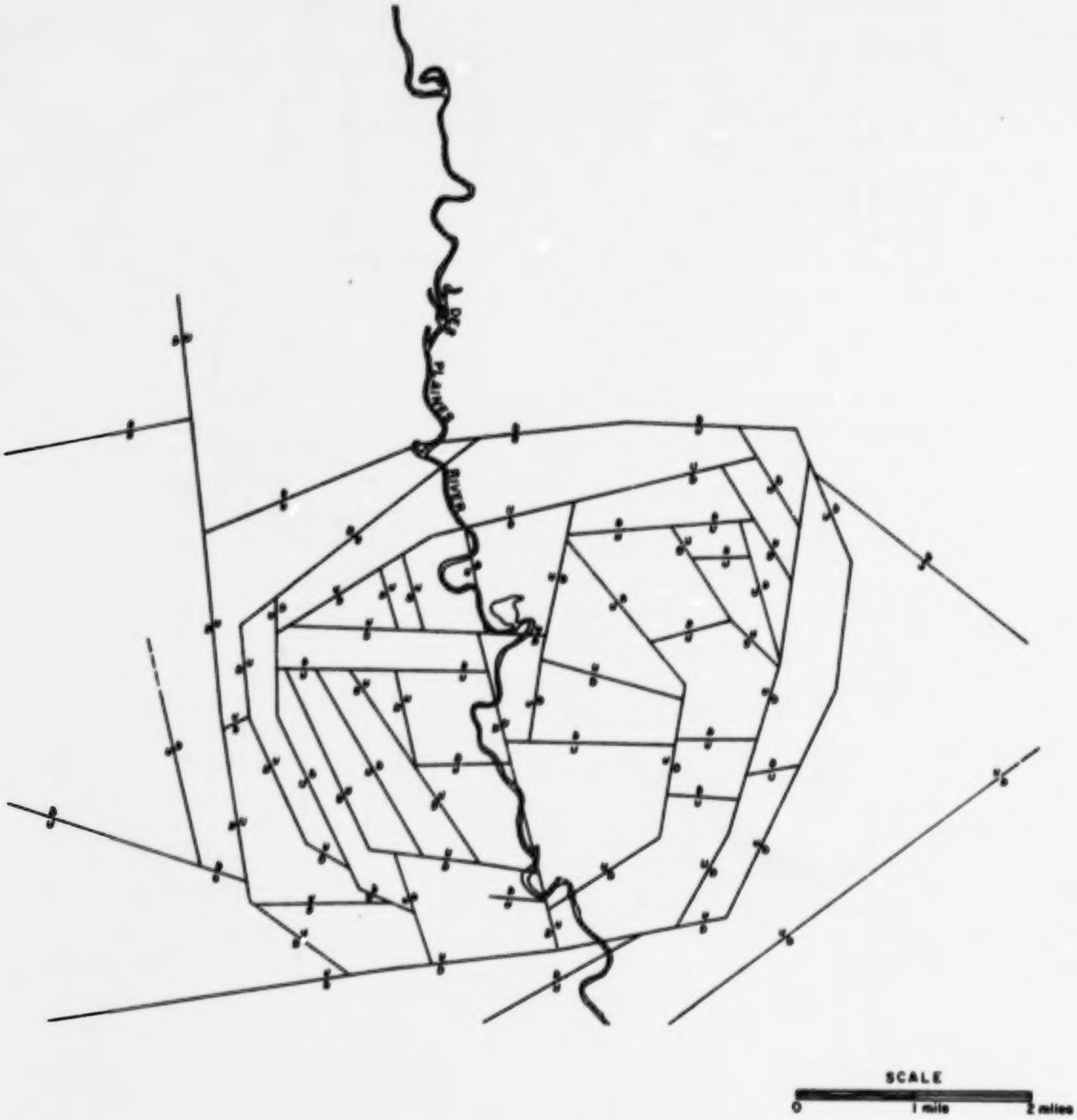
The Sandwich Fault zone extends southeastward from near Ottawa, Illinois for some 80 miles into the southern part of the Chicago area. This major fault is nearly vertical with the northern block moving down

FIGURE II-27
Fault Location Map[1]


DES PLAINES
DISTURBANCE
LEGEND

1 NEC, 1972.

FIGURE II-28
Complex Faulting
Des Plaines Disturbance[1]


DES PLAINES RIVER
SCALE
0
1 mile
2 miles

---

[1] HEC, 1972.

relative to the southern block. Maximum displacement is 900 feet 20 to 30 miles west of Chicago, but decreasing eastward. South of Joliet, another fault paralleling the main zone, shows a reversal in movement indicating a scissors-like motion. This second fault has a maximum displacement of 100 feet.

The Des Plaines disturbance, on the Des Plaines River, is a roughly circular area, 5.5 miles in diameter, of intense faulting. Numerous nearly vertical faults with displacements of up to 600 feet bring rocks as old as the Middle Ordovician St. Peter sandstone and lower Ordovician Oneota dolomite to the bedrock surface. In addition, Mississippian and Pennsylvanian rocks not found in the surrounding area have been preserved in some of the downthrown blocks.

The location of faults within, and the complexity of, the Des Plaines disturbance is indicated in Figure II-28. The Des Plaines structure is surrounded by nearly horizontal Silurian rocks in which there are, comparatively, few faults (Figure II-27). The bedrock is buried beneath 75 to 200 feet of glacial drift, and there is no indication of the structure on the present surface.[1]

Aside from these areas of major disturbances, previous exploration has indicated the existence of additional faults or fault zones within the project area. A Vibroseis survey conducted by Seismograph Service Corporation in 1968 provided the greatest overall coverage of the area. The faults mapped by this survey are shown on the Fault Location Map, Figure II-22.

Along the Mainstream, North Branch, and Des Plaines tunnels, where core drilling was done during the 1971 program, holes were drilled specifically to confirm the existence of the faults mapped by the Vibroseis survey. In the Calumet area, no drilling has been done to confirm faults indicated by Vibroseis survey.

Not shown on Figure II-27, are 86 minor faults mapped in three recently constructed tunnels. Nearly 90 percent of these faults are oriented in a northwest-southeast direction, generally parallel to the similarly trending major joint set. The remainder parallels the orientation of the northwest-southwest joint set. The number of faults found in the tunnels, appears to indicate that faulting with small vertical displacement is common in the Chicago area and that numerous small faults should be expected throughout the proposed tunnel system. A detailed description of the minor faults and a discussion of survey results are provided in Appendix C.

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[1] Willman, 1971.

2.2.4 Seismicity

From the 175-year historical earthquake record, four earthquakes were identified as significant in terms of their size and distance from the proposed project. These earthquakes occurred within 100 miles of Chicago during the recorded history of the area. In addition, a series of the most violent earthquakes in United States history occurred in 1811 and 1812 at New Madrid, Missouri, about 400 miles southwest of Chicago. Table II-9 summarizes the known earthquakes, with intensity III or greater, assumed to have been felt in the Chicago area. Based on evaluation of the historic record, the risk of impairment to the project by earthquakes is judged to be small.

The four earthquakes, identified as significant, originated at Fort Dearborn (Chicago) in 1804, near Rockford in 1909, near Aurora in 1912, and near Amboy in 1972. These earthquakes have been characterized as follows:

- 1804 Fort Dearborn earthquake. The Fort Dearborn earthquake of 1804 has been assigned an epicentral intensity of VII in the project's earthquake catalog. This earthquake has also been assigned an intensity of V to VI[1]. EQHUS[2] reports no intensity in the catalog and remarks sections, but VIII to XI on the generalized map in the inset. Considering the comparatively low population density and the probably irregular population distribution in 1804, as well as the small number of felt reports,

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[1] Docekal, J.D., Earthquakes of the Stable Interior, With Examples on the Mid-Continent, University of Nebraska, Ph.D., University microfilms, Ann Arbor, Michigan, 1970.

[2] Coffman, J.L., and von Hake, C.A., Earthquake History of the United States (EQHUS), Pub. 41-1, revised (through 1970), U.S. Department of Commerce, NOAA, Environmental Data Service, 1973, p. 37-58.

Table II-9
Summary of Earthquakes Felt in Chicago Area (Intensity III or Greater)[1]

Year	Date	Epicenter Locality	Estimated Magnitude	Intensity at Chgo. (M.M.)*	Epicenter Distance to Chgo.-Miles
1795	Jan. 8	Kaskaskia, Ill.		III	300
1804	Aug. 20	Fort Dearborn (Chgo.)	5.6	VII	15
1811	Dec. 16	New Madrid, Mo.	8.0 to 8.5		400
1812	Jan. 23	New Madrid, Mo.	8.0 to 8.5		400
1812	Feb. 7	New Madrid, Mo.	8.0 to 8.5		400
1827	Aug. 6	New Albany, Ind.	4.9		275
1833	June 9	St. Louis, Mo.	4.9		250
1843	Feb. 16	St. Louis, Mo.	6.9		250
1875	June 18	Ohio	5.6	III	225
1886	Aug. 31	Charleston, S.C.	7.6	III	800
1895	Oct. 31	Charleston, Mo.	6.8	V or VI	350
1906	May 26	Keewenaw Pen., Mi.	6.7	III or IV	375
1909	May 26	Illinois (Near Springfield)	6.4	VI or VII	75
1909	July 18	Illinois (Near Springfield)	5.6	III or IV	150
1909	Aug. 16	SW Illinois	5.7		300
1909	Sept. 27	Indiana	5.6	III	175
1912	Jan. 2	Illinois (Near Aurora)	5.4	V	75
1917	April 9	East Missouri	5.8	III	300
1925	Feb. 28	Canada	7.0	IV or Less	950
1935	Nov. 1	Canada	7.6	<V	550
1937	March 2	Western Ohio	5.9	III	200
1937	March 9	Western Ohio	5.8	III	200
1939	Nov. 23	Griggs, Ill.	5.7	III or IV	300
1939	Nov. 23	Waterloo, Ill.	5.9		300
1947	Aug. 9	S-Central, Mi.	5.4	III or IV	150
1968	Nov. 9	Illinois-Indiana Border	5.5	III	240

[1] HEC, 1975.

* Modified Mercalli Intensity scale.

and the fact that intensity V may have occurred 200 miles away in Indiana, the earthquake may well have had an epicentral intensity of about VIII. Although the location cited is 15 miles from Chicago, it is within the northern boundary of the project.

- 1811-1812 New Madrid, Missouri series. Information on the intensity at Chicago of the New Madrid, Missouri earthquakes of 1811 and 1812 is not available, and no intensity is listed in the project earthquake catalog. Nevertheless, the observed attenuation of earthquake intensity from events occurring 200 to 400 miles south of Chicago and the descriptions of effects in EQHUS and Fuller[1] suggest that any of these three earthquakes may have produced an intensity of VI to VII at Chicago.

- 1909 "Springfield, Illinois" earthquake. The so-called Springfield, Illinois event is reported with an epicentral intensity of VII in the project earthquake catalog; an intensity with which other sources agree. However, no other sources suggest Springfield, near the center of the state, to be near the epicenter. The latitude and longitude cited in EQHUS and in the project earthquake catalog is on the Wisconsin border. From the felt reports in EQHUS and other sources, the most probable epicenter was found to be in the vicinity of Aurora, approximately 35 miles from Chicago.[2] Felt reports suggest a maximum intensity of VIII in parts of Aurora and near Chicago. In the absence of specific data that would relate intensity VIII effects to softer ground and poorly constructed structures, this earthquake should be assumed to have approached intensity VIII. This event may actually have occurred closer to Chicago, or less than 35 miles away.

- 1912 near Aurora, Illinois. An epicentral intensity of VI is attributed to the Illinois earthquake of 1912, and the epicenter is recorded as being southwest of Aurora. The location indicated by the epicenteral coordinates, 41.5N-88.5W, is about 50 miles from Chicago.

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[1] Fuller, Myron L., "The New Madrid Earthquake," U.S. Department of Interior, Bulletin 394, 1912, p. 21-30.

[2] Docekal, 1970.

The following sections discuss the possible risk to the project from future earthquakes.

(1) Epicentral Location Accuracy

All of the earthquakes discussed above were located by evaluating macroseismic effects. Any of these events may actually have occurred 10 to 15 miles from the locations of maximum intensity reported in the catalogs.[1] This does not reduce the importance of the 1804 event, because it probably occurred within the boundary of the project area. However, the 1909 earthquake, near Aurora, may have occurred only five to ten miles from some of the proposed project structures. An epicentral location nearer to Chicago is supported by reports of macroseismic effects.[2] Similarly, the 1912 earthquake may have occurred 25 miles from some of the structures of the project. The foregoing is summarized in Table II-10, which also includes revised epicentral intensities from the previous section. It should be noted that these are probable epicentral intensities, not maximum intensities.

Table II-10
Revised Partial Earthquake Catalog[1]

Date	Probable Epicentral Intensity (MMI*)	Location	Probable Intensity at Chicago or the Project (MMI*)	Minimum Epicentral Distance from Project Structures (Miles)
1804	VIII	Fort Dearborn	VIII	0
1811-1812	XII	New Madrid, Missouri	VI-VII	~400
1909	VIII	Aurora, Illinois	VII-VIII	~ 7
1912	VI	SW of Aurora, Illinois	V	~ 25

* Modified Mercalli Intensity.

1 HEC, 1975.

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[1] Docekal, 1970.

[2] EQHUS and Docekal, 1970.

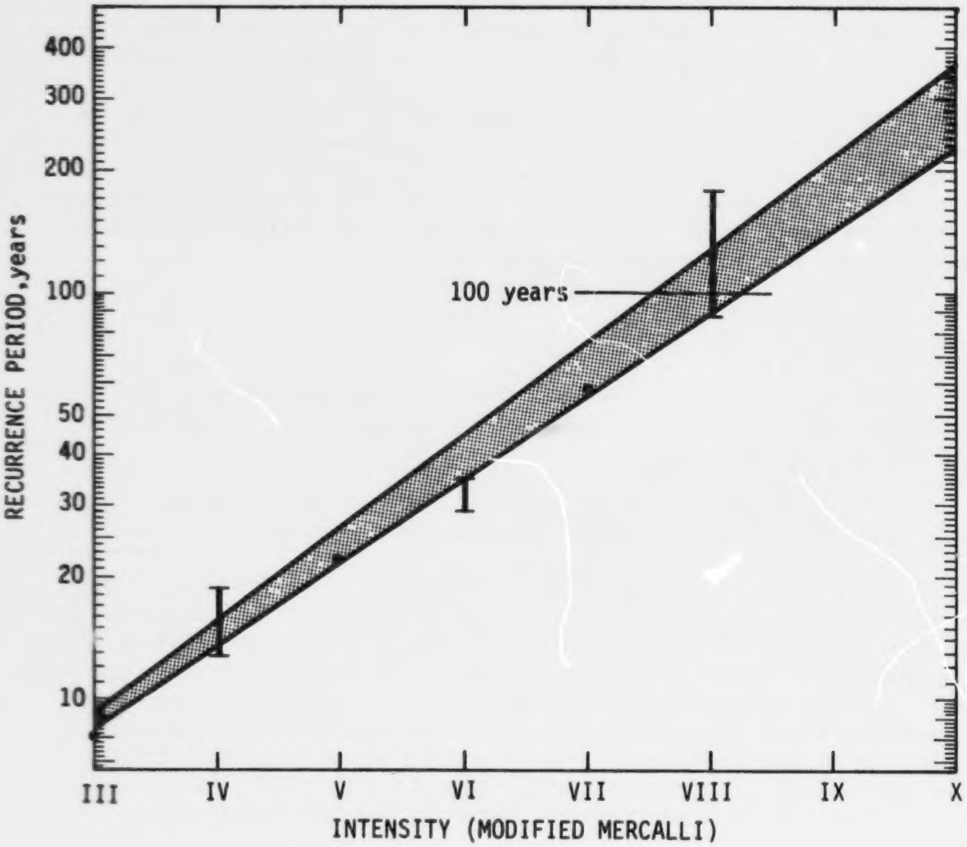
(2) Frequency, Magnitude, and Probability of Occurrence

The catalog of earthquakes felt in Chicago over about 175 years contains only four moderate earthquakes within 100 miles of Chicago, but several more distant and larger earthquakes have been felt. Of these, only the New Madrid, Missouri events significantly affected Chicago. Historical records are not sufficient to establish magnitude-frequence relationships or determine probability of occurrence. However, from the data in previous reports, suggested relationships have been evaluated between probable intensity at the project and frequency of occurrence (Figure II-29). Figure II-29 shows the recurrence period at Chicago for macroseismic effects greater than or equal to a specific Modified Mercalli Intensity (MMI). The data is drawn from Tables II-9 and II-10 and other analyses. As presented in the figure, the historical earthquake record suggests that an intensity of VIII can be expected to recur at Chicago at the rate of about once each 100 years. The figure also suggests that higher intensities might occur at longer intervals. Insofar as the historical earthquake record can be relied upon to indicate future seismicity, the higher intensity earthquakes would not be expected to occur over the life of the project because they have not occured in the recent past. Detailed evaluation of the capability of geologic structures in the Chicago region to generate earthquakes would be required to resolve the magnitude of earthquakes likely to occur.

(3) Relationships Between Faults and Seismicity

Two areas are identified as major disturbances due to faulting: the Des Plaines disturbance, within the area of the project; and the Sandwich Fault zone, approximately 30 miles to the southwest. There are 30 other faults or fault zones within the project area as revealed by Vibroseis surveys and drilling, which are not major. Eighty-six faults characterized as minor (small vertical displacement and width) were found in a sewer excavation affecting a small portion of the project area. Faults of this type can be assumed to occur through the project area. Characterization of these faults as minor may not be justified in view of the lateral nature of displacement suggested by slickensides.

FIGURE II-29
Recurrence Period for Macroseismic Effects Greater Than or Equal to Specific Intensities[1]



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[1] HEC, 1975.

Previous reports state that no evidence of activity has been observed for the faults described, however, no studies to detect fault activity appear to have been performed. Therefore, the historic earthquake record provides the best indication of activity of faults crossing the tunnels.

The 1804 Fort Dearborn earthquake occurred within the bounds of the project area. Given the lack of definitive information, it should be assumed, in order to be conservative, that this event was associated with the Des Plaines disturbance or with one or more of the faults, fault zones, or minor faults that intersect the tunnels.

The 1909 Aurora earthquake could have occurred as close as five to ten miles to the southwest of the project area. It could also have occurred on a fault that traverses the project area. In view of the local seismicity record, the faults in the project area should be assumed to be potentially active.

(4) Potential Seismic Effects

Two types of potential tunnel damage resulting from seismic activity have been identified in earlier reports:

- Dislocation of the tunnel along a fault
- Rockfalls along faults or joints.

Dislocation of the tunnel along a fault could only occur if one of the faults that intersect the tunnel is active and if an earthquake or fault creep occurred along it. Because thereis no evidence that the faults intersecting the tunnels are inactive, this sort of damage is possible in a local earthquake. Two local earthquakes have occurred in the 175-year historic record. Both may have had epicentral intensities of VIII, and presumably were associated with minor movements on faults.

Rockfalls along faults or joints could occur either from vibratory ground motion, as suggested in previous reports, or in association with dislocation on a fault which intersects one of the project tunnels. The previous reports conclude that damage to the tunnels will likely be limited to small rockfalls in a few of the highly fractured tunnel areas. This conclusion is likely to be conservative if ground motions at the surface are typically greater than those at depth at the fault site.[1,2]

In previous reports, it has been estimated that a peak particle velocity of 12 inches per second (in/s) or 30.5 centimeters per second (cm/s) will cause rock along unlined tunnels to fall out along existing cracks or joints; and a velocity of 24 in/s (61.0 cm/s) will cause new cracks to develop, along which rockfall will also occur.[3] These estimates may be somewhat high because they were developed from experience in blasting projects, however, they are useful for comparison to observed particle velocities in earthquakes.

Trifunac and Brady[4] have used a much more extensive data set than previous authors to correlate peak velocities and earthquake intensities between V and VII. The data are still insufficient for calculating mean values and standard deviations of peak velocities corresponding to other intensities. However, a projection of their data to an MMI of VIII suggests that peak vertical velocities of 38 cm/s with a standard deviation about 18 cm/s may occur. Thus, peak vertical velocity may be expected to be between 20 and 56 cm/s for about 68 percent of MMI VIII earthquakes. Because rockfall along existing joints begins at about 30.5 cm/s, rockfall could be extensive along the tunnel wherever it is intersected by other than isolated single joints. The particle velocity is still not likely to be hich enough to cause new crack formation and general rockfall.

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[1] Kanai, K., Takahashi, R., and Kawasumi, H., "Seismic Characteristics of Ground," Proc. World Conference on Earthquake Engineering, Berkeley, California, 1956, p. 31-1.

[2] Tamura, C., Mizukoshi, T., and One, T., "Characteristics of Earthquake Motion at Rock Ground," Proc. of 4th World Conference on Earthquake Engineering, Chile, 1969, No. A2, p. 26-37.

[3] Langefors, U., and Kihlstrom, B., "The Modern Technique of Rock Blasting," John Wiley and Sons, 1963.

[4] Trifunac, M.D., and Brady, A.G., 1975, On the correlation of seismic intensity scales with the peaks of recorded strong motion: Bulletin Seismological Society of America, V. 65, No. 1, pp. 139-162.

2.3 ATMOSPHERIC RESOURCES

2.3.1 Air Quality

Air quality depends on the quantity of air pollutants emitted into the air, local meteorological conditions, and topography. Since air pollutants are likely to be generated by the construction of the proposed project, it is important to analyze the current air quality of the area.

Ambient air quality is usually reported in terms of the concentration of pollutants in the air. The following substances have been identified by the U.S. EPA as air pollutants for which Federal and state air quality standards have been established: sulfur dioxide, particulate matter, carbon monoxide, hydrocarbons, photochemical oxidants, and nitrogen dioxide. Federal and state air quality standards for these pollutants are described in Appendix D. This section describes the observed 1974 air quality in the Chicago area.

Air quality in the Chicago metropolitan area is monitored primarily by the city of Chicago Department of Environmental Control and the Cook County Department of Environmental Control. These agencies have 61 monitoring stations in Cook County, including 30 within the city of Chicago. They monitor one or more of the following pollutants at each station: particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide, and oxidants. Hydrocarbons are measured at one central location by the State of Illinois EPA.

Air quality data from the above monitoring sites are published monthly and quarterly in preliminary form, and annually in final form by the Illinois EPA. The latest available data are found in the 1974 Annual Air Quality Report, and the data applicable to the Chicago metropolitan area are summarized below.

Except for nitrogen dioxide, the ambient standards for all the pollutants were exceeded at one or more monitoring sites in the Chicago metropolitan area in 1974:

- The annual primary standard of 0.03 ppm for sulfur dioxide was exceeded at the Medical Center monitor. The sulfur dioxide levels in other parts of the metropolitan area were below the standards.

- The annual primary standard of 75 $\mu g/m^3$ for particulates was exceeded at 29 monitoring sites. The 24-hour primary standard, on the other hand, was exceeded at only two sites.

- Although the one-hour primary standard for carbon monoxide was met, the eight-hour standard was frequently violated. Of the 192 violations of the eight-hour standard, 174 were recorded at the monitor next to Congress Street, a very heavily travelled commuter route.

- The annual standard of 0.05 ppm for nitrogen dioxide was met at all monitoring sites.

- The only hydrocarbon monitor, at the University of Illinois Medical Center in Chicago, recorded 67 violations of the three-hour primary standard of 0.24 ppm from 6 a.m. to 9 p.m.

- The one-hour standard of 0.08 ppm for photochemical oxidants was frequently violated at five of the ten monitoring stations in the metropolitan area.

2.3.2 Noise

Because construction of the proposed project will generate some noise, it is important to analyze the existing noise levels in the Chicago area. This section describes the existing ambient noise levels in the Chicago area in terms of the Day-Night Sound Level, L_{DN}. Other noise terminology, units, and standards are defined in Appendix E.

The existing outdoor noise levels in most parts of Chicago are primarily determined by the street traffic. Specific noise sources, such as trains, aircrafts, and industrial plants, contribute heavily to the ambient noise in nearby areas, and use of power tools, such as lawn mowers and chain saws raise the noise levels in residential areas. Whenever construction activity exists, the equipment will generate some noise.

A nationwide 100-site noise survey conducted by the U.S. EPA included several sites in Chicago.[1] Although none of the monitored sites in Chicago were located near the proposed tunnel routes, the data obtained at the survey sites may be considered as representative of the noise levels in most areas along the proposed tunnel routes.

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[1] U.S. EPA, Population Density Distribution of the United States as a Function of Outdoor Noise Levels, Vol. 2, June 1974.

The monitored sites in the EPA study were located in areas with population density varying from 6,600 to 65,000 persons/square mile. The recorded noise levels varied from a minimum of 36.3 dBA at night to a maximum of 106.2 dBA during the daytime. The L_{DN} varied from 59.0 dB to 71.2 dB. Table II-11 summarizes the EPA findings.

The data in Table II-11 do not indicate a direct relationship between L_{DN} and population density. However, the noise levels in the downtown area (sites 7 and 8) were generally higher than those in the residential areas (sites 2,3,4,5,6). The noise level at site No. 1 was the highest despite the lowest site population density, primarily because the noise monitor there was located close to an arterial street. In all cases, the outdoor noise levels are lower then those levels identified by the EPA as the limit necessary to protect the public against hearing loss (see Appendix E). However, these outdoor noise levels are generally higher than those identified by the EPA as the limit necessary to protect the public against annoyance.

Table II-11
Noise Monitoring Data for Chicago[1]

Site Number	Site Location	Population Density (people/mi^2)	Roadway Type at Site (vicinity)*	Traffic	L_{DN} (dB)
1	W. 111th St. & S. Bell Ave.	6,600	Arterial (Collector)	Cars, Trucks, Buses	71.2
2	W. 110th Pl. & S. Bell Ave.	7,400	Local (Collector)	Cars, Trucks	59.0
3	W. 73rd St. & S. Pauline Ave.	12,900	Local (Collector)	Cars, Trucks	60.6
4	64th St. & Wolcott	19,800	Collector (Arterial)	Cars, Trucks	66.9
5	71st & S. Hermitage	20,600	Collector (Arterial)	Cars, Trucks Buses	64.4
6	65th St. & S. Peoria	32,600	Local (Collector)	Cars, Trucks	63.1
7	15th St. & Drake	65,000	Collector (Arterial)	Cars, Trucks	68.4
8	W. Douglas Blvd. & St. Louis	65,000	Collector (Arterial)	Cars, Trucks Buses	70.7

* The items within parentheses refer to the roadway in the general vicinity while those without parentheses refer to the monitored site.

[1] U.S. EPA, Population Density Distribution of the United States as a Function of Outdoor Noise Levels, Vol. 2, June 1974.

III. EXISTING MAN-MADE ENVIRONMENT

III. EXISTING MAN-MADE ENVIRONMENT

This chapter contains a description of the man-made environment of the Chicago metropolitan area, which may be affected by the proposed tunneling project. The information in this chapter provides a basis to evaluate the effects of the proposed project on the man-made environment. Instead of an exhaustive inventory of the man-made environment, therefore, only those elements that are necessary for this impact evaluation are presented.

This chapter is divided into five main sections:

- Socioeconomic
- Land Use
- Resources
- Transportation
- Major Projects and Programs.

In the socioeconomic section, the current and projected population of the Chicago area is discussed. Contract construction income and employment, from primary as opposed to secondary sources, are also described.

The land use section discusses current urbanization patterns and future urbanization plans. Also identified are the archaeological, cultural, historical, and recreational sites in the Chicago metropolitan area which may be affected by the proposed project.

In the next section, the financial and labor resources of the area which may be affected by the project are discussed.

The transportation systems on which the proposed project will have an impact are also presented.

Finally, the major projects and programs possibly related to the proposed action will be described.

Each of these issues is discussed in detail in the following sections.

3.1 SOCIOECONOMIC

The current and projected demographic profile of the study area provides a basis for analyzing the socioeconomic element of the man-made environment. For the purposes of this environmental impact statement, the study area, or impact area of the proposed action, is Cook County. There are over 40 communities, including Chicago, within Cook County which are located within the service area of the Mainstream, Calumet, and Des Plaines Tunnel Systems. Demographic data will be presented in this section for Cook County, Chicago, and the Chicago Standard Metropolitan Statistical Area (SMSA) levels. Data for individual communities are contained in Appendix A.

3.1.1 Current and Projected Population

The population growth trends in the Chicago metropolitan area have been similar to those experienced in other major cities in the United States. The city of Chicago has been losing population since 1950 at an average annual rate of -.02 percent during 1950 to 1960, and at -.51 percent from 1960 to 1970. The great movement from Chicago into the suburban areas of Cook County, as well as a substantial immigration of people from the south to Cook County, occurred during the 1950's, as shown in Table III-1. The growth rate for Cook County was 13.7 percent for an average annual rate of 1.37 percent, which represents 61,570 new residents per year. During the 1960's, the greatest growth occurred in the outlying but rapidly urbanizing counties bordering Cook County, such as Du Page and Lake. Table III-2 further emphasizes the geographical redistribution of the population by presenting population share trends of the city of Chicago and Cook County, and Cook County and the SMSA. The position and proportionate population share of both Chicago and Cook County, is decreasing within the expanding SMSA.

Population projections through 1985 are presented in Table III-3. They have been based upon the more conservative OBERS projections forecast for the Chicago SMSA by the U.S. Department of Commerce. Local and regional planning groups' population projections are consistently higher than OBERS. The NIPC projection for the Chicago SMSA in 1985 is 8,750,000 compared with 7,987,800 from OBERS. The NIPC projection assumes an accellerated rate of population growth which is not consistent with growth trends for the SMSA. As shown in Tables III-1, 2, and 3, the annual growth rates have declined since 1950. Given current demographic patterns of smaller household size and a depressed birth rate, the OBERS projections which assume a slightly declining growth rate are considered more defensible.

Table III-1
Population Changes 1950-1970[1]

Jurisdiction	1970	1960	1950	Percent Change 1960-1970	Percent Change 1950-1960
Chicago	3,362,825	3,550,404	3,620,962	-5.1	-1.4
Cook County	5,488,328	5,124,489	4,508,792	7.1	13.7
Chicago SMSA	6,978,947	6,220,913	5,495,364	12.2	13.2

[1] County and City Data Book, 1972 edition, "A Statistical Abstract Supplement," U.S. Department of Commerce, Bureau of the Census, pp. 126, 550, 678.

Table III-2
Population Share Trends 1950-1970

	1970	1960	1950
Chicago as Percent of Cook County	61%	69%	80%
Cook County as Percent of SMSA	78%	82%	82%

Table III-3
Population Projections 1970-1985[1]

Jurisdiction	1970	1980	1985	Percent Change 1970-1980	1980-1985
Chicago	3,369,357	3,172,315	3,148,791	-5.8	-.71
Cook County	5,488,328	5,664,848	5,831,094	3.2	2.9
Chicago SMSA	6,978,947	7,655,200	7,987,800	9.7	4.3

[1] OBERS Projections, U.S. Department of Commerce, Bureau of the Census, p. 109.

Growth in the SMSA is anticipated to slow to an average annual rate of .97 percent through 1980 and, subsequently, to .43 percent through 1985. Chicago's population should begin to stabilize after 1980 with the projected completion of the Chicago 21 Plan for the Central Area Communities, and the South Loop New Town, which will assist the city in reestablishing vital urban neighborhoods. Several general demographic trends, which should also help stablize the higher density urban areas of Cook County and the city of Chicago in the late 1970's and 1980's are:

- The decreasing size of the household
- The increasing rate of household formation due to the increasing rate of marriage dissolution and the increasing segregation of the elderly into separate households
- The increase in numbers of all adult households
- The increase in high compensation service employment.

The above trends have been experienced in most of the large metropolitan areas in the United States. When these demographic factors are combined with the uncertainties of energy and fuel availability and the rising costs of fuel, energy, and housing, the urban centers should be strengthened and the outward population trends of the 1950's and 1960's slowed.

3.1.2 Contract Construction Income

The Chicago metropolitan area has long been a center for large-scale public and private construction projects, including mass transit system development, airport construction, and major commercial and residential development. The relatively high level of construction needs in the area has resulted in a large construction employment base. The income derived from contract construction employment from 1950 to 1971 is shown in Table III-4. Contract construction employment income exceeded two billion dollars in 1971. As shown in Table III-4, income earned from contract construction increased at a faster rate than industrial sector earnings and total personal income until 1969. In the years from 1969 to 1971, Chicago experienced a depression economy, which is reflected in the significant drop in earnings and income growth. (See Table III-4).

Table III-4
Contract Construction Income[1] - Chicago Region*
(in Millions)

Year	Contract Construction Income	Industrial Sector Earnings**	Total Personal Income
1950	$ 514.7	$ 9,286.3	$10,945.7
1959	$ 992.6	$15,365.8	$18,169.4
1965	$1,174.0	$20,126.4	$24,528.6
1967	$1,400.2	$23,452.4	$28,417.0
1969	$1,858.4	$27,468.4	$33,274.1
1971	$2,055.4	$30,426.5	$37,299.6
Percent Increase 1950-1959	92.9%	65.5%	66.0%
Percent Increase 1959-1969	87.2%	78.8%	83.1%
Percent Increase 1969-1971	10.6%	10.8%	12.1%

* The region is defined as the SMSA plus Kendall, Grundy, and Kankakee Counties.

** Earnings include only wages and salaries.

[1] Illinois State and Regional Economic Data Book, 1973 Edition, State of Illinois Department of Business and Economic Development, p. 70.

Secondary employment earnings related to contract construction in the Chicago region cannot be determined. Goods and services of several industries are directly involved with construction activity, such as trucking, finance and insurance, real estate, manufacturing, and wholesale and retail trade. Trying to derive construction-related income for a specific region or jurisdiction would be highly speculative. However, the economic benefit or multiplier of construction employment income could be up to 1.8 on a secondary basis. Table III-5 shows the proportionate share of contract construction earnings to total earnings (wages and salaries) within the Chicago region. Contract construction income has accounted for about eight percent of total Chicago regional earnings since 1969.

Table III-5
Contract Construction Earnings as
Proportionate Share of Total Earnings - Chicago Region[1]

Year	Contract Construction Earnings		Total Earnings	
	Millions	Percent	Millions	Percent
1950	514.7	6.5	7,964.1	100.
1959	992.6	7.5	13,208.9	100.
1965	1,174.0	6.7	17,404.1	100.
1967	1,400.2	6.9	20,409.1	100.
1969	1,858.4	7.7	24,203.2	100.
1971	2,055.4	7.7	26,790.3	100.

[1] Illinois State and Regional Economic Data Book, 1973 edition, State of Illinois Department of Business and Economic Development, p. 70.

Average monthly wages for construction employment are high, relative to other industries in the Chicago metropolitan area. Average wage levels are shown below:

Industry	Average Monthly Wages (Jan.-Mar.) 1970	1971	1972
Selected Industries, Total	$675	$709	$ 764
Mining	845	921	961
Contract Construction	927	986	1,099
Manufacturing	717	755	826
Transportation, Communication and Public Utilities	777	811	961
Wholesale and Retail Trade	577	604	644
Finance, Insurance, and Real Estate	696	743	800
Services and Miscellaneous Industries	576	610	640

Source: Illinois State and Regional Economic Data Book, 1973 Edition, Bureau of Employment Security, Illinois Department of Labor, p. 81.

Current monthly wages in contract construction have been estimated at $1,653, based on 1,800 hours per man-year at an average hourly rate of $11.02. Estimated 1976 union labor rates for the major trades in contract construction were published in "Engineering News Record," and are shown in Table III-6. These rates are considered to be appropriate for the Chicago metropolitan area.

3.1.3 Contract Construction Employment

Contract construction employment in the Chicago metropolitan area naturally fluctuates according to the magnitude of construction activity generated by both the public and private sector. Levels of construction activity are influenced by national economic conditions, the status and availability of Federal program assistance, and state and local government spending programs. The city of Chicago has been particularly successful in obtaining Federal program assistance for urban renewal, model cities, and other assisted housing development. The following examples typify major public construction and development projects which occurred in the Chicago metropolitan area during the past two decades:

- University of Illinois Circle Campus
- Mc Cormick Place Convention Center
- Rapid transit development and expansion
- Expansion and improvements at O'Hare Airport
- Civic Center - a complex of Federal and local government office buildings
- Major expansions in infrastructure - particularly schools and sewage system facilities.

Private sector activity has been consistently strong in the metropolitan area over the past 20 years, as well. During the past ten years, several major projects were initiated and completed in the city of Chicago, particularly

Table III-6
Current Union Hourly Wage Rates[1]

Worker Class	Dollars/Hour
Common Laborer	
Heavy Construction	8.80
Building Construction	8.80
Skilled Laborer	
Bricklayer	11.63
Carpenter	11.69
Structural Iron Worker	13.17
Plasterer	10.92
Electrician	12.94
Steam Fitter	12.37
Equipment Operator	
Hoist-One Drum	12.50
Tractor (including dozer)	11.20
Tractor - Scraper (15-16 c.y.)	11.20
Power Crane	12.50
Motor Grader	12.50
Air Compressor	10.05
Air Tool	9.105
Truck Drivers	
Dump Truck (4 c.y.)	8.90
Dump Truck (4 c.y.)	9.15
Average Hourly Rate	11.02

[1] "Engineering News Record," January 1, 1976, p. 28.

the downtown area, which added significantly to the demand for construction services; these projects include:

Project	Year Completed	Cost
Sears Tower and Plaza	1974	$150 million
Water Tower Place	1975	$150 million
Standard Oil Building	1974	$150+ million
CNA Center	1974	$ 80 million
Illinois Center (One, Two)	1969, 1972	$ 83+ million
Marina City	1966	$ 40 million
First National Bank Complex	1973	$150 million
John Hancock Center	1969	$100 million
Hyatt Regency	1974	$ 45 million
Total		$948 million

Much of the above activity was stimulated by the public sector construction which began to revitalize the older downtown areas.

The construction-related employment opportunities in the Chicago SMSA have established a skilled labor force which is predominantly unionized, and have accounted for approximately 61 percent of total construction employment in Illinois in 1970. Table III-7 presents construction employment levels for Illinois, Cook County, and the Chicago SMSA in 1970. Table III-8 reflects the fluctuation construction employment levels for the Chicago region for 1967, 1969, and 1971. As shown, the industry added over 19,000 jobs in one 2-year period and then dropped 8,161 jobs in the succeeding 2-year period. The industry is flexible and can expand or contract rapidly given the demand for construction services.

Table III-7
Construction Employment by Area - 1970[1]

	Civilian Labor Force	Total Employed	Construction Employment	Construction Employment as Percent of Total Employed
Illinois	4,591,634	4,419,915	225,416	5.1
Chicago SMSA	2,954,153	2,852,017	136,897	4.8
Cook County	2,355,804	2,269,683	99,866	4.4

[1] County and City Data Book, 1972 Edition, "A Statistical Abstract Supplement," U.S. Department of Commerce, Bureau of the Census, pp. 128, 550, 680.

Table III-8
Change in Construction Employment Level Chicago Region 1967-1971[1]

	1967	1969	1971
Chicago Region	123,048	142,180	134,019

1 Illinois State and Regional Economic Data Book, 1973 Edition, State of Illinois Department of Business and Economic Development, p. 80.

The past few years of national economic recession and the cutbacks in Federal and local program spending have had a significant impact on the construction industry employment levels. Current construction employment estimates for the Chicago SMSA and State of Illinois are shown in Table III-9.

Table III-9
Current Construction Employment Levels[1]

	1970	1975*	Percent Decrease
Illinois	225,416	185,800	17.6
Chicago SMSA	136,897	119,000	13.1

1 Division of State and Area Monthly Surveys, Bureau of Labor Statistics, U.S. Department of Commerce, November 1975.

* Private communication, MSDGC, verbal estimate.

The overall impact was apparently more severe in other regions of the state given the 17.6 percent drop in employment in Illinois as compared to the 13.1 percent drop in Chicago.

3.2 LAND USE

The current and future land uses near the proposed TARP project are described in this section. Archeological sites, present and planned cultural sites, and historical sites are also presented as well as the locations of existing and planned recreational sites near the proposed tunnel system.

3.2.1 Current Urbanization Patterns

The current land uses in the vicinity of the proposed Mainstream Tunnel are described below for the land within 500 feet of the tunnel route, the proposed locations of drop shafts and construction shafts, and access shafts. Consequently, this section is limited to only the planned land uses and facilities within these 500-feet limits.

(1) Tunnel Route

Most of the land bordering the tunnel route is zoned as general and heavy manufacturing districts, but not all of the land is intensely used. In these districts there are underutilized industrial yards, some little used and obsolete railroad yards, large areas used for employee parking, and a few vacant parcels located mostly at the banks of the Sanitary and Ship Canal and the Chicago River. Other land uses along the route include restricted manufacturing districts, commercial districts, and a few residential areas. The following discussion treats, in more detail, four segments of the proposed route, the Chicago River North Branch, Chicago River from Lake Michigan to Wolf Point, Chicago River South Branch, and the Sanitary and Ship Canal.

The North Branch flows through one of the city's most important industrial areas, the North Branch Industrial Area. Land uses along the tunnel route are mostly industrial yards, parking areas, and materials storage areas of manufacturing plants. Other uses include two boat storage yards, several docking facilities, and several vacant areas. Two relatively large vacant parcels are in the vicinity of Leavitt Street and Diversey Avenue on the east bank of the North Branch. They both border high-rise apartment complexes built along North Leavitt Street between West Oakdale Avenue and North Hoyne Avenue, which are the only residential areas along this segment of the tunnel route. A larger vacant parcel is located along the east bank between West Belmont Avenue and West Addison Street.

Along the Chicago River from Lake Michigan to Wolf Point is the city's Central Business District. Zoning in this area allows for a commercial-manufacturing district on the north side of the river from Lake Michigan to St. Clair Street, and for residential-business planned developments elsewhere. Examples of the latter type are the Marina Towers and the Illinois Center.

Along the part of the tunnel route which follows the South Branch, land tends to be less intensely used than along the two segments discussed above. There are large industrial storage yards and rail/truck container yards which appear to be underutilized. Other predominant land uses are industrial parking areas and materials storage areas. Numerous vacant parcels line the route as well. They are predominantly located between the river bank and industrial properties. In this area, the MSDGC owns a relatively large parcel at the end of the South Fork of the South Branch, bordered by South Racine Avenue and West Pershing Road.

Where the tunnel route follows the Sanitary and Ship Canal, land is used less intensely than along the other tunnel route segments. Much of the property along the north side of the canal is owned by MSDGC, and much of the remaining property is either industrial yards with large underutilized portions, or vacant. Along the south side of the canal, more land along the tunnel route is used as industrial yards, industrial parking, and materials storage. There are also numerous vacant parcels which are found mostly between the canal bank and industrial properties or railroad spurs.

With the exceptions of the underutilized and vacant areas, all of the land which borders the tunnel route is very important to the economy of the city of Chicago.

(2) Potential Rock Disposal Areas

Rock accumulated from tunneling operations will be of a type similar to currently quarried rock in the metropolitan area, such as rock from McCook and Thornton quarries. These two quarries have temporary storage capacity for rock prior to its sale for commercial use. The largest rock size expected from tunnel excavations will be about three inches in diameter, and the rock will be roughly cubical in shape. Stearns quarry is presently not used and is capable of accepting large quantities of nonsaleable fill from TARP. Nonsaleable fill includes rock fines and clayey or flint-like rocks which make up the majority of the excavated material. All of these quarries are located in industrial areas.

(3) Potential Tunnel-Sludge Disposal Areas

Approximately 32 percent of the metropolitan area's sewage sludge is shipped to the MSDGC's 10,000-acre landfill in Fulton County. The balance of the sludge is distributed to the NuEarth Program, broker sales, Landale Lagoons, and landfill. Although only a few suitable landfill sites exist in the metro area, the Fulton site is capable of accepting additional sludge removed from the proposed tunnels.

3.2.2 Urbanization Plans

This section describes the relationships between the city's land use plans and the existing land use along the proposed tunnel route, and at existing sites which could be used for the disposal of excavated rock and dredged sludge from the tunnels.

(1) Tunnel Route

Many existing manufacturing, commercial, and business establishments along the proposed tunnel route are important to the area's economy. Therefore, no plan or action by the city is likely to propose or execute any significant changes to restrict existing intense use along the tunnel route. Rather, proposed plans focus on identifying underutilized lands, and transforming them into contemporary urban environments.

An example is the proposed South Loop New Town and Riverfront Plan. The plan proposes development of a new in-town community of 120,000 on 335 acres comprised of 210 acres of obsolete railroad yard, 75 acres of publicly owned land and facilities, and 50 acres of land in marginal industrial and commercial use on the east side of the South Branch, south of the Loop. This plan would approximately double the city's central area population. Along the east bank of the South Branch, the plan recommends the replacement of existing railroad yards with institutional development such as schools, libraries, and health care centers to serve the new town and recreational sites, including landscaped open space. The plan is part of a larger plan for the central area called the Chicago 21 Plan, which will affect existing land uses near the proposed tunnel route. These effects will include:

- Establishment of a River Zone along the Chicago River and creation of guidelines for improving the use and environment of adjacent lands
- Replacement of elevated rapid transit tracks with subways to encourage redevelopment, including:
    - Wells - Franklin Street Corridor
    - Wacker Drive - Lake Street Corridor
    - Illinois Center
    - Zones outside the Loop which provide commercial support services to the Loop area
- Provision for public development and continuous street level, predestrial-oriented shopping in the State Street - Dearborn Street Corridor
- Strengthening and improvement of industry, concentrated in the North Branch Industrial Area.

The Riveredge Plan, also part of the Chicago 21 Plan, would affect redevelopment along the Main Branch of the Chicago River. It recommends separate plans for guiding development in the built-up sector, Wolf Point to Michigan Avenue, in the new development sector, Michigan Avenue to Lake Shore Drive, and in the river entrance sector, Lake Shore Drive to Lake Michigan. In addition, it calls for an historical sites designation program and a fine arts program which are described in Sections 3.2.4 and 3.2.5.

Along the Sanitary and Ship Canal, the existing industries are flourishing and are not likely to relocate, because they depend on the low-cost water transport on the canal. Hence, land use in this area can be expected to remain about the same. If proposed plans such as TARP project are executed, expected improvements in water quality in the canal might attract additional water-using industry to this area.

(2) Potential Rock Disposal Areas

The operating quarries are likely to continue in operation, while Stearns quarry will probably be filled up eventually and possibly used as a park.

The Chicago Lakefront Plan has several alternatives. One alternative recommends landfilling along the Lake Michigan shoreline and constructing numerous islands about a mile off shore. This operation could provide adequate sites for rock excavated from TARP tunnels. The other alternatives will also require landfilling and recommend the following:

- Expansion of the park base through shoreline extension. This landfill would complete a continuous public shoreline, add new parkland, and strengthen the shoreline to withstand erosion.
- Breakwater construction and shoreline extension and creation of sheltered water areas which increase shore protection and provide opportunities for small boating, swimming and fishing.

Overall, the Lakefront Plan depends on suitable excavated material from the TARP project to construct these new land forms.

(3) Potential Tunnel-Sludge Disposal Areas

The metropolitan area will probably continue to rely on the Fulton County site for disposal of sewage sludge, including tunnel sludge cleaned from TARP tunnels.

3.2.3 Archeological Sites

The Loop area along the proposed tunnel route has been filled with at least 18 feet of soil since the first settlements in the Chicago River flatlands. In addition, the course of the Chicago River has been changed, and this involved extensive earthmoving. The Sanitary and Ship Canal is entirely man-made, and comprises a large segment of the proposed tunnel route. No important archeological remains are known to exist along the route.

Any archeological sites which may have existed at potential rock disposal or sludge disposal areas cited above have probably been destroyed or covered with fill.

3.2.4 Cultural Sites

The cultural sites along the proposed Mainstream Tunnel route are in the central business district. A list of important architectural sites located within 500 feet of proposed drop shafts and construction shafts is given below, as compiled by the MSDGC:

- Tribune Tower, Michigan Avenue & Illinois Avenue
- Equitable Building, Michigan Avenue & Kinzie Street
- Wrigley Building, Michigan Avenue & Kinzie Street
- Executive House Hotel, Wabash Avenue & Wacker Drive
- Merchandise Mart, Franklin Street & Kinzie Street
- Sears Tower, Wacker Drive & Adams Street.

There are several sites on the river edge of the central business district near proposed surface construction areas which contain fine art. This art, described in the Riveredge Plan as important to the city's cultural heritage, includes:

- Washington-Morris-Salomon Memorial Sculpture in Herald Square

- Equitable Plaza and Fountain

- Bas-relief sculptures on Michigan Avenue Bridge

- Busts of men of commerce at Merchandise Mart Plaza

- Various works of art at newly developed portions of Randolf Terminal properties.

The Riveredge Plan would include a fine arts program to acquire, locate, and maintain art work in public places. Two sites within 500 feet of proposed TARP surface construction are possible sites for major fine arts projects, they are: Wolf Point promontory, and the Michigan Avenue end of the Illinois Center Esplanade.

3.2.5 Historical Sites

While no National Register properties are located within 500 feet of proposed tunnel construction sites or finished facilities, a few historical sites are nearby. These sites are:[1]

- Fort Dearborn, Michigan Avenue & Wacker Drive
- Washington-Morris-Salomon Memorial, Michigan Avenue & Wacker Drive
- Mud Lake, Ridgeland Avenue & 47th Street.

The Chicago 21 Plan recommends that two areas, northern Astor Street and southern Prairie Street, be declared historical preservation areas. Neither of these areas will be affected by the proposed tunnel project.

The city's Riveredge Plan recommends that numerous historical sites be marked to indicate their general significance and their historical relationship to the Chicago River Main Branch. Markers would be placed at the following sites which are within 500 feet of TARP surface construction:

- Early Wolf Point Settlement
- Sauganash Hotel, 1828; First U.S. Post Office, 1833; Republican Wigwam, 1860
- First Public School, 1833
- DuSable House, 1779
- Fort Dearborn Site, 1803
- Heald Square, 1926, and Washington-Morris-Salomon Memorial, 1941.

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[1] From list compiled by MSDGC and based on Chicago Landmark, 1975, Commission on Chicago Historical and Architectural Landmarks, May 1975.

3.2.6 Recreational Sites

Along the proposed tunnel route, the existing recreational sites are the borders of the Chicago River in the central business district. These areas are used for recreational walking, sightseeing, fine arts exhibits, and other cultural exhibitions.

The Riveredge Plan would provide for increased river-oriented open space; small parks, public properties, and pedestrian facilities along the 1.5-mile bank of the Chicago River between Lake Michigan and Wolf Point.

Other sites could be developed along the South Branch if water quality and flood control projects, such as the TARP project, were executed. Less flood danger combined with redevelopment such as the proposed riverfront improvements of the South Loop New Town Plan would make recreational use possible for existing unutilized or underutilized land.

3.3 RESOURCES

The following two sections discuss financial and labor resources. The first section provides an analysis of the financial resources available to fund the Mainstream Tunnel System and the other two tunnel systems, and the second section presents a profile of the labor force in the Chicago metropolitan area.

3.3.1 Financial

This section discusses the financing schedule and availability of pollution control funds for:

- The MSDGC's Flood and Pollution Control Program
- The Mainstream Tunnel system (water pollution control tunnels only)
- The total Tunnel Plan (water pollution control tunnels only).

In addition, this section addresses the availability of funds for certain elements of the MSDGC's Flood and Pollution Control Plan, which are not part of the Tunnel Plan and which are closely related to the overall goal of meeting the 1983 water quality standards. These elements include:

- Instream aeration
- TARP storage reservoirs
- Increases in treatment levels, efficiencies, and plant capacities.

Both existing and potential funding sources are considered for the pollution control aspects of the program and for the key elements which are not part of the Tunnel Plan to assess how much financial assistance current programs might provide and to indicate how these programs must be augmented to complete program implementation. The impact of the Tunnel Plan on the MSDGC's property tax rate is also considered, and the annual sequence of anticipated contract award dollars is identified for the construction of the Tunnel Plan projects. The fund commitment schedule is also presented, indicating anticipated sources necessary for the support of this award program. The data and analyses presented in this section indicate that the financing requirements of constructing the tunneling portion of TARP can be met. In addition, it can be reasonably assumed that the financing requirements of other key elements of the MSDGC's Flood and Pollution Control Plan associated with meeting 1983 water quality standards (instream aeration and expansion of the North-Side and Calumet treatment facilities) can be met. In the case of the West-Southwest treatment plant expansion project, the financing feasibility is very doubtful. Finally, financing for the TARP storage reservoirs is nonexistent. The complex issue of the authority of the Corps of Engineers in the case of urban drainage improvement projects is currently under consideration. However, there is presently no congressional appropriation and no request from the U.S. Army Corps of Engineers for an appropriation to help support the construction of the TARP reservoirs.

(1) Construction Cost Schedule

The total Chicago Flood and Pollution Control Program has two major parts; TARP, to correct the combined-sewer overflow problem, and a series of projects identified by the MSDGC. Major goals of this series of projects include:

- Increases in treatment levels, efficiencies, and plant capacities
- Extensions and enlargements of interceptor sewer facilities
- Flood control in separate storm sewer areas
- Waterway dredging
- Provision of sludge handling facilities.

Table III-10 presents the MSDGC construction and financing schedule designed to meet the 1983 goals of the Federal Water Pollution Control Act (PL 92-500) and the flood control abatement objectives. The schedule requires that project awards be forthcoming through FY 1986. The table presents a summary of the Flood and Pollution Control Plan by major category and anticipated award levels. The cost projections are based on 1975 construction costs and incorporate a six percent annual cost escalator. Although the sewer construction cost index rose 20 percent in 1974 and rose an estimated 12 to 13 percent in 1975, the consensus of opinion among Federal and business financial leaders is that the inflation rate will stabilize at five to seven percent over the next decade. The six percent escalator thus represents a reasonable expectation in terms of the future impact of inflation on the relevant construction cost figures. The plan has a total expected cost of approximately $3.54 billion, of which approximately $1.84 billion is associated with TARP. Of the $1.84 billion, elements related to water pollution control account for approximately $1.03 billion and measures related principally to flood control for $.81 billion.[1]

Table III-11 presents the construction and award schedules for the Mainstream Tunnel system. The estimated construction cost for the Mainstream tunnel (in 1975 dollars, escalated six percent annually) is

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[1] This $.81 billion primarily includes the TARP storage reservoirs and Phase II tunnels.

Table III-10

MSDGC Flood and Pollution Control Plan - Implementation Schedule[1]

Program*	Fiscal Year											
	76	77	78	79	80	81	82	83	84	85	86	Totals
Sewers	56.3	59.4	11.0	0.1	2.0							128.8
Plant Improvements	176.3	19.3	120.1	282.8	281.5	222.0						1,102.0[2]
Solids Disposal	24.2	8.0	31.6	66.5	4.5	4.0	4.0					142.8
Instream Aeration	2.8	13.9										16.7
TARP												
No Cost Escalator	111.2	338.7	282.9	205.8	200.4	115.8	159.0	73.5	32.4	5.7	2.2	1,527.6
Six Percent Annual Escalator	111.2	359.0	317.9	245.1	253.0	155.0	225.5	110.5	51.6	9.6	3.9	1,842.3
Flood Control	8.6	26.2	10.2	3.6	0.5		0.3	0.1	2.5			52.0
Total Annual Awards												
No Cost Escalator	379.4	465.5	455.8	558.8	488.9	341.8	163.3	73.6	34.9	5.7	2.2	2,969.9
Six Percent Annual Cost Escalator	379.4	493.4	512.1	665.7	617.2	457.3	231.6	110.7	55.6	9.6	3.9	3,536.5

1 Figures are derived from the data presented in the MSDGC Facilities Planning Study, revised version dated January 1975

2 Includes the $124 million already obligated for the O'Hare Treatment Plant Project

* All figures are in $ millions.

Table III-11

Construction Award Schedule for the Mainstream Tunnel System and the Total Tunnel Plan*

Construction Contracts	Fiscal Year											
	76	77	78	79	80	81	82	83	84	85	86	Totals
Addison to Wilmette	11.6	15.4	15.4	15.4	15.4	15.2	7.7					96.1
59th to Central	2.2	8.8	8.8	8.8	8.8	3.1						41.4
Central to Damen	2.8	11.0	11.0	11.0	11.0	11.0	3.2	1.4				62.4
Damen to Roosevelt		7.8	9.5	9.5	9.5	9.5	7.2	2.2	2.2	0.1		57.5
Roosevelt to Ogden		2.6	10.6	10.6	10.6	7.3	1.4	1.4	0.1			44.6
Ogden to Addison		6.2	7.5	7.5	7.4	7.4	4.7	1.3	1.3			43.3
North Branch Chicago River			1.5	5.7	5.7	5.7	5.7	5.8	1.8	1.6		33.5
Pumping Station			4.1	8.2	8.2	8.2	5.7					34.4
Mainstream Tunnel System	**											
No Cost Escalator	16.6	51.8	68.4	76.7	76.6	67.4	36.5	12.1	5.4	1.7		413.2
Six Percent Annual Cost Escalator	16.6	54.9	76.9	91.4	96.7	90.2	51.8	18.2	8.6	2.9		508.2
Total Tunnel Plan	***											
Six Percent Cost Escalator	50.7	92.2	159.8	183.5	189.9	173.0	95.7	57.5	22.2	5.7	2.2	1,032.4

* The figures (in $millions) represent the construction costs of the mainstream tunnels, drop shafts, connecting structures, and drop shaft grouting.

** Figures are derived from data provided by the Office of the Technical Project Officer (MSDGC TARP Project), Region V EPA.

*** Figures are based on data supplied by MSDGC in January 1976.

$508.2 million. Approximately 84 percent ($87.0 million in 1975 dollars) of the connecting structure and drop shaft costs have been determined by EPA to be eligible for construction grant funds under the Federal Water Pollution Control Act Amendment of 1972 (PL 92-500).[1] The other 16 percent is associated with flood control benefits and is, therefore, ineligible for pollution control funding. The last line of the table represents the construction cost schedule for all of the tunnel systems (Mainstream, Calumet, and Des Plaines systems). The estimated construction cost of all of the tunnels (in 1975 dollars, escalated six percent annually) is $1.0322 billion. The annual operating and maintenance costs for the Mainstream Tunnel system are estimated to be approximately $472,000; the estimate for the entire tunnel system is $1.0 million annually.

(2) Sources of Funds

Certain funds are either already available or may be requested under existing legislation for implementing a part of the total Flood and Pollution Control Plan. These funds are derived from local, State, and Federal sources. The Federal sources include grant programs involving water pollution control, flood control, urban renewal, and recreation facilities development. This section focuses on the sources of pollution control funds for implementing the Mainstream Tunnel system.

1. Metropolitan Sanitary District of Greater Chicago (MSDGC)

The MSDGC customarily finances construction and facilities replacement by proceeds from the sale of construction bonds. The District is authorized to incur indebtedness in an amount not to exceed five percent of its total assessed valuation. As of January 1, 1976, the unexercised debt-incurring capacity is $718.5 million.

Prior to 1971, the plan to issue bonds required a referendum. In 1971, however, a bill was enacted authorizing the issuance of up to $380 million in general obligation construction bonds without referendum. The MSDGC can issue these bonds at a maximum rate of $100 million per year, plus carry-over of the unused portion of that rate from previous years. The bonds must be repaid within 20 years from the date of issuance.

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[1] The figure of 84 percent may not hold for the other two tunnel systems. Certain costs for the Calumet and Lower Des Plaines systems are still under review with no final conclusions derived to date.

In support of existing national and state goals, the District has already issued $249.5 in Capital Improvement Bonds and has remaining unused authority to issue $130.5 million of additional bonds. Approximately $66.3 million of the remaining authorization is targeted by the MSDGC for the Tunnel Plan.

The present authorization of the District to issue bonds for pollution control work is based on previous water quality standards. Since water quality standards have become more stringent, the MSDGC is currently formulating plans to ask Illinois for an increased bonding authority in the vicinity of $200-400 million. In view of the District's AA bond rating and additional dept-carrying capacity, additional bond funds in the range of $200-300 million should be available in the near future at a reasonable interest rate.

The MSDGC is also authorized to levy an _ad valorem_ tax for construction purposes in an amount not to exceed $.26 for each $100 of assessed valuation. Table III-12 presents an estimate of the change in property tax rate attributable to the anticipated Tunnel Plan financing requirements.

2. State of Illinois

By approval of the bond issue referendum of 1969, the State of Illinois was authorized to issue bonds up to a maximum of $750 million. Approximately $150 million of these funds have already been raised through bond sales leaving approximately $300 million potentially available (by agreement with the State) to the District for implementing the Tunnel Plan. For FY 1976, the statewide appropriation of these funds is $206 million; therefore, it would be unreasonable to expect that a major portion of this potential $300 million would be available in FY 1976 to the MSDGC for the Tunnel Plan. A conservative posture would suggest that approximately $300 million would potentially be available to the District in FY 1976-1977.

Table III-12
1976 Estimate of the Change in Property Tax Rate Attributable to the Tunnel Plan

Fiscal Year	Cost of Tunnel Plan ($Millions)	Incremental Change in Tax Rate ¢/$100 Assessed Valuation	Cumulative Change in Tax Rate ¢/$100 Assessed Valuation
76	50.7	0.47	0.47
77	92.2	0.73	1.20
78	159.8	1.29	2.49
79	183.5	1.28	3.77
80	189.9	1.17	4.94
81	173.0	2.08	7.02
82	95.7	(0.42)	6.60
83	57.5	(0.46)	6.14
84	22.2	(0.22)	5.92
85	5.7	(0.30)	5.62
86	2.2	(0.30)	5.32

Assumptions:

- MSDGC's share of construction costs is 25 percent
- MSDGC financing is accomplished with 20-year bonds, 5 1/2 percent coupon
- TAX BASE ($22.7 billion in 1975) is escalated at six percent annually
- Operating/maintenance cost not included in Tunnel Plan cost figures
- Effect of construction grant program disbursement schedule on MSDGC is not considered.

1 This represents a 13.3 percent increase over the 1975 MSDGC tax rate of $.4005 per $100 of assessed valuation.

The State's ability to raise funds in the general obligations municipal bond market is good, as exemplified by its AA bond rating, which should ensure that funds can be raised at reasonable coupons. The prospects of future or increased bonding authorization are extremely bleak because of lack of political feasibility and the requirement for referendum.

3. Federal (PL 92-500)

Of the total $18 billion appropriation under PL 92-500, the State of Illinois was allocated a total of $1.137 billion ($125 million in FY 1973; $187.5 million in FY 1974; $252.3 million in FY 1975; and $571.0 million in FY 1976). By virtue of the State's priority scheme, the MSDGC anticipates that approximately 50 percent of the funds will be allocated for its Water Pollution Control Program. Substantial portions of FY 1973-1975 funds have already been obligated to the District. The major obligations include:

- $43.65 million for the O'Hare Sewer Project
- $49.22 million for the North Shore section of TARP (Addison-Wilmette)
- $93.0 million for the construction of the O'Hare Treatment Plant Facilities.

Unobligated Federal funds currently total approximately $646.1 million ($5.5 million FY 1973 and 1974 funds; $68.9 million FY 1975 funds; and $571.7 million FY 1976 funds). FY 1975 and prior years' funds must be obligated by June 30, 1976; FY 1976 funds must be obligated by September 30, 1977. Of this $646.1 million funds total, approximately $323.1 million will be available to the MSDGC in FY 1976 and 1977. The Illinois priority scheme for the allocation of these remaining funds to the District provides that:

- Mainstream tunnels, drop shafts, and connecting structures receive 100 percent priority

- Calumet segment of TARP receives a partial priority[1]

- The Des Plaines segment of TARP receives a low priority[2].

EPA headquarters has requested an increase of $42 billion in the future Federal Pollution Control funding authorization under PL 92-500. EPA recommends an annual appropriation of $7 billion for FY 1977-1982. Staff members of the Senate Public Works Subcommittee have indicated that the Office of Management and Budget (OMB) recommendation to the President will probably entail a multiyear appropriation of $5 billion annually. The staff also indicated that the allocation scheme used to parcel out funds to the states is likely to change. The FY 1973-1976 funds ($18 billion) were allocated primarily on the basis of needs, as defined in the 1974 Needs Survey. Under this scheme several states (including New York, California, Illinois, Michigan, New Jersey, Ohio, and Pennsylvania) were allocated over 50 percent of the total appropriation. The allocation of the State of Illinois has averaged approximately 6.32 percent. EPA headquarters has recommended a formula which would give equal weight both to state needs (as defined in the 1974 survey) and to projected state population in 1990. It is reasonable to expect that a formula similar to this will be adopted by Congress and applied to the FY 1977 appropriation. The impact of this change in the allocation formula would be to reduce Illinois' share of future national appropriations to approximately 5.2 percent. Even if the allocation formula remains the same, the state's share of the national appropriation is expected to decline somewhat because its needs have been declining as a result of employing Pollution Control Bond funds. The MSDGC's share of future Federal water pollution control appropriations is conservatively estimated to be 50 percent over the FY 1977-1982 period. Assuming a $5 billion annual appropriation and a 5.2 percent allocation to the State of Illinois, the District could reasonably expect $780 million of additional Federal funds available over FY 1977-1982.

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[1] The Calumet system has some Step 2 and Step 3 projects in funding rang

[2] The Lower Des Plaines system has some Step 2 projects within funding range.

(3) Tunnel Plan Financing Schedule - Currently Available and Additionally Required Funds

To complete the Tunnel Plan, the financing schedule must coincide with the design and construction schedules. Table III-13 presents the award schedules anticipated for Mainstream Tunnel system, total Tunnel Plan, and the total Flood and Pollution Control plan. The table also depicts the financing schedule necessary to support the implementation of the Tunnel Plan. This same schedule can be used to assess the financing feasibility of the Mainstream Tunnel system.

The table shows that the existing available funding from the Federal Government, the State, and the MSDGC is sufficient to implement the Mainstream Tunnel System. Additional Federal Water Pollution Control funds of approximately $220.0 million and MSDGC funds of approximately $73.5 million will be required to meet the implementation schedule for the total Tunnel Plan. In view of the sound fiscal posture of the MSDGC, the high priority assigned TARP by the state, and the very conservative estimates of future Federal appropriations, it can be reasonably assumed that the future financing requirements can be met.

(4) Financing of Maintenance and Operations Costs

For maintenance and operations, the District is authorized to levy an ad valorem tax in an amount not to exceed $.37 for each $100 of assessed valuation, less the amount received pursuant to the Industrial Waste Surcharge Ordinance. The State statute also contains authority to impose a user charge which is currently required under PL 92-500.

Despite the fact that many municipalities historically have funded operation and maintenance costs of treatment facilities by imposing ad valorem taxes, this system does not provide incentives for domestic and low-volume commercial users to conserve water. EPA headquarters has contended, however, that "a properly formulated user charge system based on ad valorem taxes is a viable and appropriate method of funding operation and maintenance costs."[1] Region V EPA has

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[1] Letter from EPA Administrator Russell E. Train to House Speaker Carl Albert, February 3, 1975.

Table III-13
Financing Schedule - Tunnel Plan and Mainstream Tunnel System

Fiscal Year	Awards Schedule ($Millions)			Fiscal Year	Funding Sources ($Millions)					
					Federal (EPA)		State		MSDGC	
	Total Flood Control and Water Pollution Control Plan	Tunnel Plan	Mainstream Tunnel System		Existing	Additional** Requirement for Tunnel Plan	Existing	Additional** Requirement for Tunnel Plan	Existing	Additional** Requirement for Tunnel Plan
76	379.4	50.7	16.6	76	372.6*	-	300	-	66.3	-
77	493.4	92.2	54.9	77		-		-		-
78	512.1	159.8	76.9	78	-	-	-	-	-	-
79	665.7	183.5	91.4	79	-	-	-	-	-	-
80	617.2	189.9	96.7	80	-	-	-	-	-	-
81	457.3	173.0	90.2	81	-	82.4	-	-	-	27.8
82	231.6	95.7	51.8	82	-	71.8	-	-	-	23.9
83	110.7	57.5	18.2	83	-	43.1	-	-	-	14.4
84	55.6	22.2	8.6	84	-	16.7	-	-	-	5.5
85	9.6	5.7	2.9	85	-	4.3	-	-	-	1.4
86	3.9	2.2	-	86	-	1.7	-	-	-	.5
Total	3,536.5	1,032.4	508.2		372.6	220.0	300	-	66.3	73.5

* Includes approximately $49.6 million already obligated to the North Shore section of Mainstream TARP (Addison-Wilmette segment).

** Assumes required financing will be forthcoming: 75 percent from Federal and state sources and 25 percent from the MSDGC.

awarded two grants to the MSDGC to develop a user charge system to comply with the requirements of PL 92-500. The final system will probably be based on water usage (as opposed to ad valorem taxes) with several categories of user charge schedules.

(5) Major Non-Tunnel Plan Elements; Currently Available and Additionally Required Funds

This section addresses the financing schedule and availability of funds for certain elements of the MSDGC's Flood and Pollution Control Plan, not part of the Tunnel Plan, which are closely associated with the overall goal of meeting 1983 water quality standards. These elements include:

- Instream aeration to add dissolved oxygen to the waterway system receiving plant effluents
- Increases in treatment levels, efficiencies, and plant capacity
- Excavation of three TARP storage reservoirs to provide for capture of remaining pollutant discharges to prevent backflows to Lake Michigan and to provide for flood control.

1. Instream Aeration

In terms of project phasing and priorities, instream aeration stands directly behind the Tunnel Plan (tunnel systems, drop shafts, and connecting structures).[1] Instream aeration is not a treatment system and is thus not eligible for FWPCA funding. The funding requirement (approximately $16.7 million for a series of eleven batteries of diffusers located adjacent to and parallel to the banks of the waterway) will most likely be met from the $300 million of State funds targeted for the MSDGC or from funds raised by the District through an anticipated increased or additional bonding authorization.

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[1] MSDGC Facilities Planning Study, January 1975, p. M-XI-14.

Funding of instream aeration with the currently available State funds would increase the additional funds required by the MSDGC to implement the Tunnel Plan, from $73.5 million to $90.2 million (see Table III-13). In view of the sound fiscal posture of the MSDGC, it can reasonably be assumed that the future financing requirements can be met.

2. Treatment Plant Improvements

Treatment plant improvements (North-Side, Calumet, West-Southwest plants) require an estimated $1.17 billion. Construction of the O'Hare treatment plant is currently in progress; the project entails an estimated cost of $124 million, of which EPA has obligated $93 million in Step 3 FWPCA funding, and the MSDGC is funding the remainder.

In terms of priorities, the treatment plant expansions at Calumet (estimated cost of $352.8 million) and North-Side (estimated cost of $152.3 million) stand directly behind instream aeration.[1] According to current estimates, these two projects will be ready for Step 3 FWPCA funding in January and July of 1979, respectively. The West-Southwest treatment plant expansion project (estimated cost of $666.3 million) is currently expected to be ready for Step 3 FWPCA funding in December 1979.[2]

Focusing on the higher priority Calumet and North-Side projects (estimated combined cost of $505.1 million), it is anticipated that sufficient FWPCA and MSDGC funds will be available to finance them. As discussed in a previous section of this report, the MSDGC can reasonably expect $780 million of additional FWPCA funds over the FY 1977-1982 period. An estimated $220.0 million (see

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[1] MSDGC Facilities Planning Study, January 1975, p. M-XI-14.

[2] The cost estimates for the three treatment plant projects are based on the estimates provided in the MSDGC's Facility Plan (January, 1975). These estimates were in 1975 dollars and had to be escalated for the assumed 6 percent annual inflation rate.

Table III-13) of this total is required for implementation of the Tunnel Plan. The remaining $560 million of Federal funds would more than cover the required $378.8 million (75 percent of $505.1 million) for the Calumet and North-Side treatment plant expansion projects. The MSDGC's share of the two projects ($126.3 million) will increase the District's additional funding requirement from $90.2 million (additional funds required for the Tunnel Plan and instream aeration) to $216.5 million. In view of the MSDGC's AA general obligation bond rating and its current formulation of plans to ask Illinois for an increased or additional bonding authority in the vicinity of $200-400 million, it is reasonable to expect that the Calumet and North-Side treatment plant expansion projects can be financed.

For the West-Southwest treatment plant expansion project, the financing feasibility is very doubtful. According to current estimates, this project will not be ready for Step 3 FWPCA funding until December 1979. The remaining portion of the $780 million of FWPCA funds estimated to be available to the MSDGC for the period FY 1977-1982, would fall short by approximately $318.5 million, if it were obligated to the West-Southwest treatment plant expansion project.[1] In addition, the funding of this project would increase the MSDGC's additional funding requirement from $216.5 million to $383.1 million. The projected shortfall in Federal funds and the significant increase in MSDGC funds required combine to make the funding feasibility highly doubtful for the West-Southwest treatment plant expansion project.

3. Reservoirs

The estimated cost of the three TARP storage reservoirs (Upper Des Plaines, Mainstream, and Calumet systems) is $471.6 million in 1975 dollars.[2]

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[1] EPA's portion of this project would be approximately $499.7 million; the MSDGC's portion would be $166.6 million.

[2] Addition of the flood control tunnels raises this figure to approximately $.81 billion in 1975 dollars escalated 6 percent annually.

The benefits derived from the construction of the reservoirs primarily are control of overbank flooding and decrease of flood discharges into the downstream reaches of the waterways. EPA headquarters has, therefore, determined that the reservoirs are not eligible for FWPCA funding.

The reservoirs, however, could potentially qualify for Federal flood control funding. The Flood Control Act of 1937 established the principle of Federal participation in flood control projects. The 1944 Flood Control Act redefined flood control to include channel and major drainage improvement. In practice, however, this authority (drainage improvement) has only been applied to the agricultural area. There is no precedent for Federal participation (drainage improvement) in urban applications such as the TARP reservoirs.

The Corps of Engineers is now in the process of determining the Federal interest in providing funding for the total Underflow Plan. The Chicago District Corps of Engineers has prepared a report entitled Urban Water Damage Study, The Chicagoland Underflow Plan, dated December 1975. Final recommendations regarding the division of Underflow Plan responsibilities depend on the character and degree of interest at EPA headquarters. The Chicago District has sent the report to the Office of the Chief of Engineers, North Central District of the Corps of Engineers.

In view of the complexity of the question concerning the role of the Corps of Engineers in urban drainage improvement, it is unlikely that the TARP storage reservoirs can reasonably expect any Federal flood control funding in the near future. In conclusion, the financing feasibility of the reservoirs is currently nonexistent.

3.3.2 Labor

This section provides a general profile of Chicago's labor force and should be reviewed in conjunction with Section 3.1.3 which discusses in detail the contract construction labor force.

The Chicago metropolitan area labor force is diverse. Traditionally, it has drawn workers from nearby states and from rural areas in the south as employment opportunities have increased or were perceived to be better than those elsewhere in the south and central United States. In 1970, the Chicago SMSA civilian labor force comprised 64 percent of the total Illinois labor force. Labor force characteristics for 1970 are detailed in Table III-14. The labor force is predominantly male, with women comprising approximately 40 percent of the civilian labor force in 1970. Total white collar workers comprised 53 percent of the labor force in the Chicago SMSA in 1970.

Unemployment rates obtained from the Bureau of Labor Statistics, U.S. Department of Commerce are shown below:

Jurisdiction	Rate	Date
State of Illinois	8.7%	November 1975
Cook County	9.6%	October 1975
City of Chicago	11.2%	October 1975

National unemployment for the third quarter was 8.4 percent. Chicago's employment profile is heavily dependent upon manufacutring and nonservice employment, all of which were more vulnerable to the economic recession than other employment types. Two other general trends that will contribute to the Chicago area's keeping a relatively high unemployment rate are higher productivity and labor force growth. Nationwide, productivity increased faster than employment during the busy recovery period of 1970 to 1973 and this is expected to happen again during 1975 to 1978.[1]

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[1] Fortune Magazine, November 1975, p. 22.

Table III-14

1970 Labor Force Characteristics[1]

							Percent of Employment Distribution						
	Civilian Labor Force	Percent Female	Total Employment	Manufac-turing	Wholesale and Retail Trade	Services	Educ. Services	Con-struction	Govern-ment	Profes-sional/ Managerial	Sales and Clerical	Crafts-men, Foremen	Percent Unemployed
City of Chicago	1,451,432	41.3	1,387,908	32.0	20.0	8.3	5.5	3.7	13.1	17.8	30.0	12.7	4.4
Chicago SMSA	2,954,153	38.7	2,852,017	31.7	20.8	7.4	6.2	4.8	11.7	23.0	30.0	13.9	3.5
Cook County	2,355,804	39.4	2,269,683	31.3	21.0	7.7	6.0	4.4	11.8	22.0	30.8	13.5	3.7

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[1] County and City Data Book, 1972 Edition, "A Statistical Abstract Supplement," U.S. Department of Commerce, Bureau of the Census, p. 128, 550, 680.

The labor force is also growing because of an increasing participation rate among women. It is unlikely that this trend will reverse itself in the next decade.

3.4 TRANSPORTATION

Surface roadways and waterways are likely to be affected by the construction and operation of the proposed tunneling project. Therefore, this section describes the existing conditions of highways, streets, and waterways in the project service area which might be affected.

3.4.1 Highways and Streets

The roadways that are likely to be affected by the proposed project primarily include those to be used by trucks transporting rock and spoil material from construction sites to disposal areas. Since no decision on the disposal method has yet been made, exact locations of disposal sites and, hence, truck routes cannot be identified. If McCook and Stearns Quarries are used for disposal of the rock and spoil material from the Mainstream Tunnel system, the most likely truck routes would be as follows:

- From the Addison Street construction shaft to Stearns Quarry via Western Avenue, Cermak Road, and Halsted Street
- From the Roosevelt Street construction shaft to Stearns Quarry via Wells Street, Harrison Street, and Halsted Street
- From the Damen Avenue construction shaft to Stearns Quarry via 28th Street, Western Avenue, Cermak Road, and Halsted Street
- From the Central Avenue construction shaft to Stearns Quarry via Stevenson Expressway, Damen Avenue, and Archer Avenue.

Of the roadways mentioned above, Stevenson Expressway is a limited access multilane highway. It is a major commuter highway with average daily traffic (during 1972 and 1973) of about 118,000 vehicles including 9,200 trucks.* Route 66 is a four-lane highway with average daily traffic of 28,700 including 1,300 trucks, again based on the 1972 and 1973 data.

Recent traffic data for the other streets are not available. However, traffic data collected in 1967 are available for some of the streets mentioned above and are shown in Table III-15.

Table III-15
Average Daily Traffic Volume on Streets Likely to be Affected by the Proposed Project[1]
1967 Counts

Roadway	No. of Lanes	Average Daily Traffic (Vehicles/Day)
Addison St.	2	20,400 at Western Ave.
Archer Ave.	4	19,000 at Damen Ave.
Cermak Rd.	2	23,800 at Western Ave.
Halsted St.	2	13,900 at Cermak Rd.
Western Ave.	6	32,700 at Addison St.

[1] Traffic Map, Chicago, Illinois, prepared by Illinois Department of Public Works and Buildings, Division of Highways, Bureau of Planning, 1967.

3.4.2 Waterways

This section describes transportation activities on the waterways in the Chicago metropolitan area. General information concerning the waterways is given in Section 2.1.1. Harbors and waterways in the Chicago metropolitan area are shown in Figure III-1. The discussion in this section is presented as follows:

- Navigational season
- Water level
- Cargo movement.

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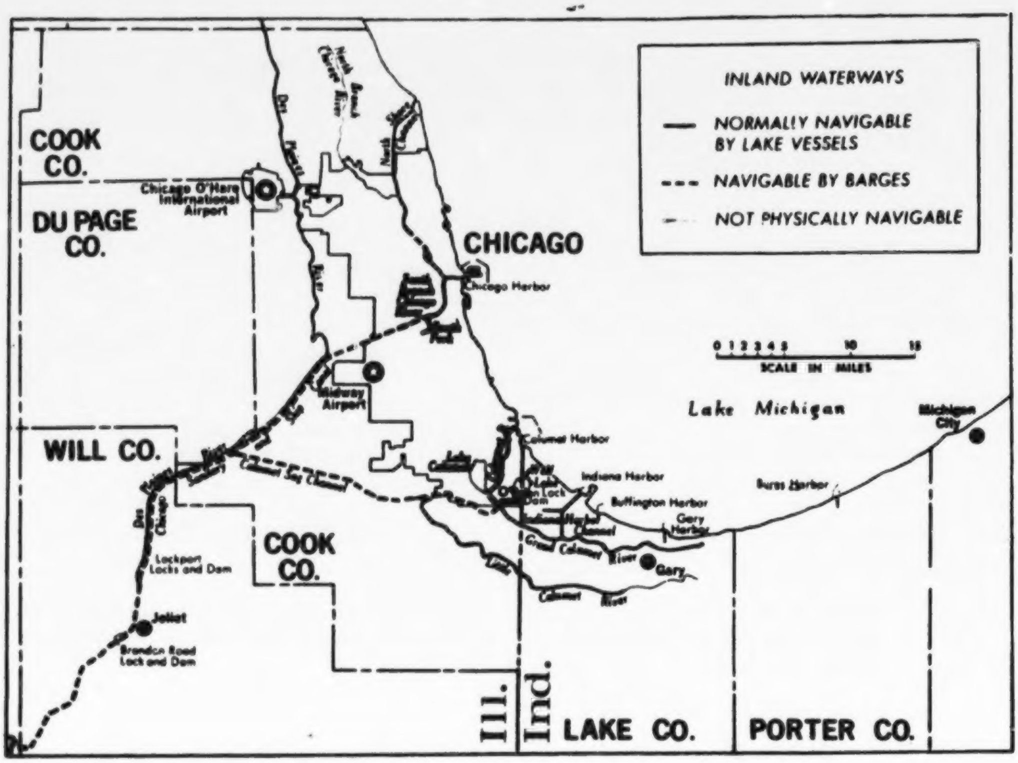
* Based on maps prepared by the Illinois Department of Transportation, Office of Planning, Programming, and Environmental Science.

FIGURE III-1
Harbors and Waterways of
the Chicago Area[1]


INLAND WATERWAYS
NORMALLY NAVIGABLE BY LAKE VESSELS
NAVIGABLE BY BARGES
NOT PHYSICALLY NAVIGABLE
COOK CO.
DU PAGE CO.
Chicago O'Hare International Airport
North Branch Chicago River
Des Plaines River
North Shore Channel
CHICAGO
Chicago Harbor
0 1 2 3 4 5 10 15
SCALE IN MILES
Lake Michigan
Michigan City
Midway Airport
WILL CO.
Calumet Sag Channel
Calumet Harbor
Lake Calumet
Indiana Harbor
Burns Harbor
Buffington Harbor
Gary Harbor
Grand Calumet River
Gary
Little Calumet River
Lockport Locks and Dam
COOK CO.
Joliet
Brandon Road Lock and Dam
Ill.
Ind.
LAKE CO.
PORTER CO.

Harbors and Waterways of the Chicago Area. (Updated from Mid-Chicago Economic Development Study, Mayor's Committee for Economic and Cultural Development of Chicago, 1966.)

[1] Booz, Allen & Hamilton, Identification of Facilities at the Port of Chicago, for State of Illinois Department of Business and Economic Development, June 1975.

(1) Navigational Season

Commercial traffic uses Calumet Harbor throughout the year. The general navigation season for Chicago harbor extends from April to December.

For the years from 1959 through 1974, the opening date varied from April 8 to May 25, and the closing date varied from December 2 to December 17.[1]

(2) Water Level

The depths of the waterways vary with location. The minimum depth in the waterways or segments of waterways is termed the controlling depth. As of June 30, 1974, the controlling depth was nine feet for the Chicago Sanitary and Ship Canal, the Calumet-Sag Channel, and the Little Calumet River and Calumet River from the east end of the Calumet-Sag Channel to Turning Basin No. 5 in the Calumet River.[1] The controlling depth in the Chicago River varies from nine feet in the South Branch to 21 feet in the North Branch.

(3) Cargo Movement

The Chicago waterways play an important role in area waterborne commerce. Of the 46.155 million tons of waterborne freight traffic through the Port of Chicago in 1969, 17.268 million tons moved over the inland waterways.[2] During 1974, the freight movement over the waterways grew to 37.2 million tons.[2] The waterway traffic growth patterns in the State of Illinois are shown in Figure III-2.

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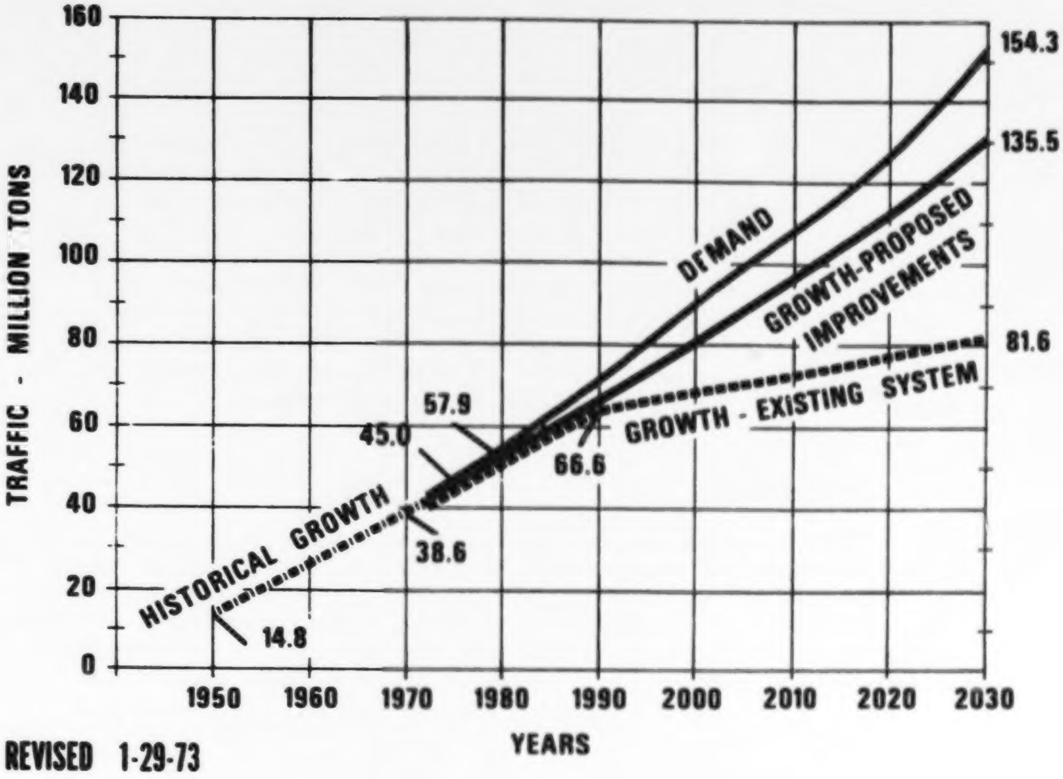
[1] Booz, Allen & Hamilton, Identification of Facilities at the Port of Chicago, for State of Illinois Department of Business and Economic Development, June 1975.

[2] Booz, Allen & Hamilton, Economic Analysis of the Port of Chicago, for the State of Illinois, Department of Business and Economic Development, November 1975.

FIGURE III-2
Illinois Waterway Traffic
Growth[1]



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[1] MSDGC, Environmental Impact Statement Related to the Tunnel and Reservoir Plan, November 1973.

The facilities along some portions of the Chicago River handle deep draft traffic (draft greater than nine feet) and the remaining waterways accommodate shallow draft barge traffic.

3.5 MAJOR PROJECTS AND PROGRAMS

This section describes those capital projects costing over one million dollars of various local, state, and Federal government agencies and of private firms, which would be constructed in the area of the proposed Mainstream Tunnel project.[1]

3.5.1 Transit Improvements

The Core System is part of the Chicago Urban Transit District's Chicago Central Area Transit Project (CCATP). The Core System is the highest priority system of the project and is now in the design phase. Two subway additions would be built in the Core System; the Monroe Street Line and the Franklin Street line. The estimated cost of these additions is $1.4 billion.[2]

Predesign work has been deferred on the other components of the CCATP.

3.5.2 Street Improvements

The most costly proposed project which would cross the tunnel route is the Crosstown Expressway. The expressway would connect the junction of the Edens and Kennedy Expressways to the Dan Ryan Expressway by following Cicero Avenue to 75th Street. The new expressway would cross the tunnel route along Cicero Avenue. It is estimated at a cost of about $1.1 billion during the construction period from 1975 to 1985.

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[1] The chief reference for this section is "City of Chicago 1975-1979 Capital Improvements Program," Department of Development and Planning, city of Chicago, 1975.

[2] "Chicago Urban Transit District Annual Report 1974," December 31, 1974.

Next most costly is the proposed construction of Columbus Avenue from Monroe Street to Wacker Drive and from the north side of the Main Branch to Ontario Street. This would cost $44.4 million from 1975 to 1979.

The proposed relocation and construction of Lake Shore Drive from Monroe Street to Wacker Drive during 1975 to 1979 is estimated at a cost of $27.4 million.

In a joint city/county project, Ashland Avenue will undergo widening and re-curbing from 83rd Street to Addison Street at a cost of about $2 million. Ashland Avenue would cross the proposed tunnel route along the South Branch.

3.5.3 Rail and Truck Terminal Improvements

The vicinity of the proposed tunnel route is a major transportation corridor for railways and trucks. New facilities will be added during the period from 1976 to 1995 and presently underutilized facilities will be used for other purposes. Details of proposed rail and truck terminal improvements can be found in "Recommendations for the Chicago Area Freight System for 1995."[1] The recommendations suggest no major alterations of the existing pattern of rail and truck terminal development.

3.5.4 Public Acquisition of Energy-Utility Corridor

The reference cited above also recommends the public purchase of a right-of-way along part of the north side of the Sanitary and Ship Canal which coincides with the proposed Mainstream Tunnel Route. Presently, privately owned rights-of-way along the canal are used for transmission lines by Commonwealth Edison electric utility and by Natural Gas Pipeline Company of America for 24-, 36-, and 42-inch diameter gas pipelines. No petroleum pipelines currently use rights-of-way along the canal.[2]

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[1] Chicago Area Transportation Study, CATS project 364 08, February 1974.

[2] "Freight Facility Compendium," Chicago Area Transportation Study, CATS project 354 04, April 1972.

The public right-of-way would concentrate future utility lines in a single right-of-way to make better use of land resources while accommodating the growing residential and industrial energy needs. Under the proposed acquisition program, the state would purchase those parts of the designated energy-utility corridor which might be in danger of being abandoned. Lands would be classified as "land-bank property," and funds derived from the sale or lease of the right-of-way would be used to repay principal and interest.

Costs of reserving the right-of-way in the area of the proposed tunnel route, the corridor would consist of EJE and Commonwealth Edison rights-of-way near the canal and the Belt Railway and Western Avenue Railway corridors cross the canal at right angles.

3.5.5 Additions to Public Buildings

An addition is planned to the Lane Technical High School near the proposed drop shaft number 85 and the two proposed construction shafts just south of Addison Street on the east side of the North Branch.

No other addition plans in the area of the proposed tunnel project are currently being contemplated.

IV. SUMMARY OF ALTERNATIVES

IV. SUMMARY OF ALTERNATIVES

Several basic alternatives have been considered to resolve the flooding and pollution problems of the Chicago metropolitan area. These alternatives are:

- Separate sewers, which provide a separate storm sewer line parallel to existing sanitary sewers and involves laying over 440 miles of additional lines under city streets
- Collect discharges from 640 outfalls into 340 collection basins and provide surface or subsurface storage at or near each of those outfalls
- Ultimate surface collection, which conveys and collects wastewaters from the 340 basins into several large reservoirs or storage basins
- Tunnels and reservoirs (TARP) which is similar to ultimate surface collection except conveyance is done by deep tunnels.

It is EPA's opinion that these alternatives have been thoroughly weighed and evaluated in past studies and that the proposed action (TARP) is clearly the most effective and least costly. The following sections summarize many of the options which have been analyzed over the past five years[1] and highlights the events leading up to the selection of TARP.

4.1 ALTERNATIVE PLANS

During the past 20 years, numerous plans to solve the flooding and water pollution problems in the Chicago metropolitan area have been developed by government agencies, local organziations, and individuals. The early plans focused mainly on flood control, but as degradation of water resources continued to increase, plans began to address water pollution control. Promulgated water quality standards and Lake Michigan backflow regulations also influenced the development of additional plans.

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[1] Based on information presented in the Flood Control Coordinating Committee report, "Summary of Technical Reports - Alternatives," August 1972.

In November 1970, the Flood Control Coordinating Committee (FCCC) was reactivated to review and evaluate the plans developed and formulate additional ones to address both the flooding and water pollution problems. The committee consisted of representatives from the State of Illinois, Cook County, the MSDGC, and the city of Chicago. Twenty-three alternative plans were evaluated in detail with respect to possible facility sites, sizes, and costs. Alternatives were selected for detailed study if they met overall objectives. Details of the process used in this selection are presented in Section 4.1.2. The overall project objectives were established by the MSDGC to comply with Illinois Pollution Control Board (IPCB) standards, and are as follows:

- Prevent all backflows to Lake Michigan to protect water supply resource
- Reduce pollutant discharges caused by combined-sewer overflows
- Reduce flooding in the combined-sewer and downstream areas.

A chronology of the plans proposed and studies performed during the past 22 years is provided in Appendix G, "Chronology of Important Events - 1954 through 1975."

The first section of this chapter identifies the alternative plans evaluated by the FCCC from 1970 to 1972 and the additional plans developed since 1972. In the following sections, the evaluation process used is discussed, as well as the consequences of the "no action" alternative.

4.1.1 Description of Plans

This section provides a brief description of the plans proposed to solve the flooding and water pollution problems in the Chicago metropolitan area.[1] The plan designation indicated in parentheses are found in the FCCC's report, "Development of a Flood and Pollution Control Plan for the Chicagoland Area" (August 1972). The plan descriptions were extracted from this report.

(1) Original Deep Tunnel Plan with Mined and Surface Storage in the Calumet Area (Alternative A)

The original Deep Tunnel plan was outlined in the Harza-Bauer Reports of 1964, 1966, and 1968. The 1964 report proposed large tunnels under the waterways to store and convey the overflows from combined-sewers to treatment points. The 1966 and 1968 reports proposed a series of tunnels in the Niagaran and Galena-Platteville rock strata to convey the combined sewage to a single storage location in the Calumet vicinity. Mined storage volumes would be provided in the Galena formation. Surface storage, in conjunction with mined storage, could be used for power generation. Captured combined-sewer overflows would be treated at the Calumet Sewage Treatment Plant and at a new plant constructed nearby. Variations of these plans considered underground storage in other locations, such as under the North-Side Treatment Plant.

(2) Deep Tunnel Plan With Pumped Storage Power (Alternative A_p*)

This plan is the Deep Tunnel plan, as described above, with mined and surface storage in the Calumet area. The plan includes pumped-storage power as a source of revenue benefits.

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[1] The Metropolitan Sanitary District of Greater Chicago, "Environmental Impact Statement," preliminary draft, November 1973.

* The subscript "$_p$" indicates a power generation plan for the alternative plan of the same letter. The flood and pollution control features of the basic plan are still retained in the "p", designated plan, except where noted.

(3) Deep Tunnel Plan With Mined and Surface Storage in the Calumet and Stickney Areas (Alternative B)

The plan, proposed in the Harza-Bauer Report of November 1968, included a series of tunnels in the Niagaran and Galena-Platteville formations to convey combined sewage to storage locations in the vicinity of the West-Southwest and Calumet Sewage Treatment Plants. Mined storage volumes would be provided in the Galena-Platteville formation. Survace storage in conjunction with the mined volumes could accommodate peaking power generation.

(4) Deep Tunnel Plan (Calumet, Stickney Storage) With Pumped Storage (Alternative B_p)

The Deep Tunnel plan described above (Alternative B) included a variation which would utilize pumped-storage power as a source of revenue benefits.

(5) Deep Tunnel Plan With Mined and Surface Storage in the Calumet, West-Southwest and North-Side Sewage Treatment Plant Areas (Alternative C)

This plan is a modification of Alternatives A and B. A series of tunnels in Niagaran and Galena-Platteville formations would convey combined sewage to the vicinities of the three major sewage treatment plants: Calumet, West-Southwest, and North-Side. Mined storage in the Galena-Platteville formations and pumping to either surface reservoirs or to constructed quarries would be optional. Captured combined-sewer overflows would be treated at the existing West-Southwest, Calumet, and North-Side Sewage Treatment Plants.

(6) Deep Tunnel Plan (Storage in Three Locations) With Pumped-Storage Power (Alternative C_p)

The Deep Tunnel plan described above (Alternative C) includes a variation which would utilize pumped-storage power as a source of revenue benefits.

(7) State of Illinois, Division of Waterways Plan (Alternative D)

The Waterway Improvements plan outlined in the Illinois Division of Waterways Report of November 1968, included channel improvements and treatment of combined-sewer overflows. Waterway improvements would comprise a ten-foot widening and deepening of the Calumet-Sag Canal and the Chicago Sanitary and Ship Canal up to Throop Street, removal of Brandon Road Lock and Dam, and reconstruction of the Lockport Lock and Dam. This plan was subsequently updated to delete the channel improvements and to provide for 341 detention basins near major outfall points that would be connected to MSDGC interceptor sewers for the controlled release of detained combined-sewer flow.

(8) Composite Plan (Alternative E)

The Composite plan, outlined in the city of Chicago, Bureau of Engineering Report of September 1968, included a series of tunnels in Niagaran and Galena-Platteville formation to transfer overflows to the West-Southwest, Calumet, North-Side, or O'Hare Sewage Treatment Plants. Volumes of mined storage, surface storage, pit or quarry storage, tunnel capacity, and pumping capacity would be optimized. Mined storage areas at several locations would be included to reduce tunnel sizes. Captured combined-sewer overflows would be treated at the West-Southwest, Calumet, North-Side, and O'Hare Sewage Treatment Plants.

(9) Chicago Underflow Plan - Lockport (Alternative F)

The Underflow plan, as outlined in the city of Chicago, Bureau of Engineering Report of May 1970, included a series of conveyance and storage tunnels to increase conveyance to Lockport, to provide the required storage volumes in the tunnel systems, and to provide for the treatment of the captured volumes either through existing plants or new facilities at Lockport. The system would have an outlet below the Lockport Dam. Tunnels would slope to existing and proposed wastewater treatment plants where captured combined-sewer overflows would be pumped to treatment.

(10) Chicago Underflow Plan - Single Quarry (Alternative G)

The Single Quarry plan by the city of Chicago, Bureau of Engineering, comprised a series of tunnels in the Niagaran formation to convey combined sewage to a pit in the McCook area. Flow into the pit would be by gravity during storms. The tunnels would be dewatered by pumping the tunnel volume to the pit. Captured combined-sewer overflows would be treated at the West-Southwest Treatment Plant.

(11) Chicago Underflow Plan - Two Quarries (Alternative H)

The Two Quarry plan proposed by the city of Chicago, Bureau of Engineering, is a modification of Alternative G, comprising a series of tunnels in the Niagaran formation which would convey combined sewage to pits in the McCook and Calumet areas. Flow into the pits would be by gravity. The tunnels would be dewatered by pumping into the pits. Captured combined sewage would be treated at the West-Southwest and Calumet Sewage Treatment Plants.

(12) Chicago Underflow Plan - Three Quarries (Alternative J)

The Three Quarry plan, a further modification of Alternative G, also proposed by the city of Chicago, Bureau of Engineering, is similar to Alternative H. Stearns Quarry, however, has been added to provide additional storage volume and to improve the hydraulic behavior of the system.

(13) Leffler Plan (Alternative K)

The Leffler plan comprises the construction of a series of dikes in Lake Michigan to develop ponds with a total area of about 14,680 acres: 3,800 acres for the North Shore Channel, 2,560 acres for the Chicago River, and 8,320 acres for the Calumet River. The plan visualizes the development of an uninterrupted highway from Wilmette to 95th Street, a series of swimming areas, skating ponds, small boat harbors, a local sightseeing highway, and a depository for river dredgings.

(14) Meissner Plan (Alternative L)

The flood control plan outlined in the Meissner Engineers Report of August 1958, comprises channel improvements, surface reservoirs, and discharges to Lake Michigan (possibly into reservoirs). More than 100,000 acre-feet of surface storage along waterways and in Lake Michigan would be provided. The main capacity would be increased to 56,000 cfs. The possible use of stone quarries to store stormwater runoff was first developed in this plan.

(15) Ramey-Williams Channel Improvement Plan (Alternative M)

This flood control plan, outlined in the Metropolitan Sanitary District of Greater Chicago Report of April 1959, was developed to correct inadequacies of the main channel outlet at Lockport. Widening improvements to the Chicago Sanitary and Ship Canal would increase the outflow at Lockport to 30,000 cfs without attaining flood stages in the waterway.

(16) Sheaffer Plan (Alternative N)

The Sheaffer plan proposes abandonment of the existing sewage treatment plants and conveyance of all combined sewage to areas in central Illinois for treatment in aerobic treatment cells with spray irrigation of effluent on underproductive farmland. This plan could be a supplement to the several containment systems, with or without the abandonment of the sewage treatment plants.

(17) Metropolitan Sanitary District of Greater Chicago Flood Control Studies (Alternative P)

A flood control project outlined in the MSDGC Report of July 1964, proposed flow diversions to the Des Plaines River at Willow Springs and at Sag Junction, removal of the rock humps at Summit, and utilization of quarries, clay pits, and surface storage for flood water storage.

(18) Four Storage Plan (Alternative Q)

The Four Storage plan is a further development of the three storage locations and three quarry plans. The plan comprises a series of separate zone tunnels and conveyance structures and storage at the four major sewage treatment plants: West-Southwest, Calumet, North-Side, and proposed O'Hare. Tunnels would be dewatered by pumping, typically to surface or pit storages at the North-Side, West-Southwest, Calumet, and O'Hare Sewage Treatment Plants. Surface storage would be provided where it would be more economical. The North-Side area storage would be in both a mined area and a surface reservoir.

(19) Four Storage Plan with Pumped Storage Power (Alternative Q_p)

The Four Storage plan described above (Alternative Q) includes a variation which utilizes pumped-storage power as a source of revenue benefits.

(20) McCook, Calumet and O'Hare Storage Plan (Alternative R)

The McCook, Calumet, and O'Hare Storage plan comprises a series of separate zone tunnels and conveyance structures and storage at West-Southwest, Calumet, and O'Hare Sewage Treatment Plants. Tunnels would be dewatered by pumping at the West-Southwest and proposed O'Hare locations. The plan would provide quarry storage in the McCook area, surface storage at the O'Hare plant, and mined and surface or pit storage in the Calumet area.

(21) McCook, Calumet, and O'Hare Storage Plan with Pumped-Storage Power (Alternative R_p)

The McCook, Calumet, and O'Hare Storage plan described above (Alternative R) includes a variation which utilizes pumped-storage power as a source of revenue benefits.

(22) Chicago Underflow Plan, McCook and O'Hare Storage (Alternative S)

The McCook and O'Hare Storage plan comprises a series of tunnels, conveyance structures, and storage at McCook and at the O'Hare Sewage Treatment Plant. Tunnels would be dewatered by pumping at the West-Southwest and O'Hare plants. The plan provides for pit storage at McCook and surface storage at the O'Hare plant.

(23) Separate System of Sanitary Sewers (Alternative T)

The Sewer Separation plan, as outlined in the city of Chicago, Bureau of Engineering Report of April 1971 (revised), developed a cost estimate for the separation of sanitary and industrial wastes from stormwater by constructing parallel sanitary sewers. The proposed separate sanitary sewers would drain into existing MSDGC interceptors for conveyance to existing wastewater treatment plants. The separate storm sewers would discharge directly to the waterways as at present. No treatment for storm sewer outflows was provided.

(24) Additional Plans

Plans developed, but not evaluated by the FCCC, are described below. Although these plans appear to be additional alternatives, they are variations or combinations of evaluated plans.

1. Original Keifer Underflow Plan

Tunnels would be constructed in bedrock approximately 200 feet below the surface to serve both as a conveyance system and as a storage facility. For larger storms, excess runoff would still be released to the waterways. After each storm the tunnel-sewer would be dewatered by pumping to the interceptor sewer. The original plan suggested that a series of special tributary sewers be installed throughout the metropolitan area with connections to large main sewers extending along the waterways. Three of these underflow sewers are now under construction.

2. Tunnel and Reservoir Plan

The Tunnel and Reservoir plan proposes a series of rock tunnels in the Niagaran formation to convey combined-sewer flows to a primary storage reservoir in the McCook area. The reservoir would be a 330-foot-deep rock quarry designed to hold 57,000 acre-feet of runoff. Additional surface storage would be provided near the proposed O'Hare Treatment Plant to serve the northwest suburbs and at Stearns Quarry to reduce peak discharge. Captured overflows from combined-sewers would be treated at the West-Southwest Treatment Plant, assuming upgrading and expansion of this plant to handle one and one-half times dry weather flow. This plan is a composite of Alternatives G, H, J, and S, which were presented on the preceding pages.

3. C-SELM Study

The Chicago South End of Lake Michigan study, reviewed by the U.S. Army Corps of Engineers, is a regional approach to wastewater management. This study assumes that some variation of an underground conveyance and storage system would be adopted to capture combined-sewer overflows. The C-SELM study goes on to discuss various methods of treatment of all wastewater flows, including advanced physical-chemical waste treatment, advanced biological waste treatment, and spray irrigation of effluent in a land treatment system.

The alternative plans can be divided into four categories: deep tunnel, underflow, waterway improvement, and surface. These categories represent different flood/pollution control schemes, which have also been evaluated.

The following listing groups the alternatives by scheme category:

- Deep tunnel plans: Alternatives A, A_p, B, B_p, C, C_p, and E
- Underflow plans: Alternatives F, G, H, J, Q, Q_p, R, R_p, S, Tunnel and Reservoir, the Original Keifer, and C-SELM
- Waterway improvement plans: Alternatives D, K, L, M, N, and P

- Surface (or near surface) plans: Alternative T and C-SELM (certain portions).

4.1.2 Plan Evaluation and Elimination

Of the 23 alternatives described in the previous sections, six alternatives were eliminated which did not meet overall project objectives. The remaining 17 plans were modified to meet the established objectives. The rationale for eliminating the six alternatives, as stated in the FCCC report,[1] is summarized in the following sections.

(1) Leffler Plan (Alternative K)

The Leffler plan did not meet the project criteria because it used the existing waterways to convey untreated combined-sewer overflows to a series of diked-in storage ponds along the Lake Michigan shoreline.

(2) Meissner Plan (Alternative L)

The Meissner plan was entirely a flood control plan. It proposed channel improvements to convey large quantities of water downstream and into Lake Michigan and to store water in surface reservoirs and quarries. No provisions were provided for the treatment of combined-sewer overflows. While the Meissner plan did not meet the criteria, some of its features have been included in other alternatives.

(3) Ramey-Williams Channel Improvement Plan (Alternative M)

This plan was a flood water routing plan, to reduce flooding through waterway improvements. It did not include provisions for water quality control and, therefore, does not meet project criteria.

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[1] The Flood Control Coordinating Committee, "Development of a Flood and Pollution Control Plan for the Chicagoland Area," Summary of Technical Reports, August 1972.

(4) Sheaffer Plan (Alternative N)

The Sheaffer plan proposed conveyance of all sanitary sewage, combined-sewer overflows, and a portion of the stormwater runoff from the separately sewered area, to remote, down-state land disposal sites. If such a plan were considered, a collecting system and local storage facilities would be required, not unlike those contained in many of the other alternatives. Therefore, the Sheaffer plan is considered an extension of these systems and not considered further.

(5) Metropolitan Sanitary District of Greater Chicago Flood Control Studies (Alternative P)

This plan is essentially an integration of several special purpose flood control projects. It does not meet project criteria because water quality considerations were not included.

(6) Separate System of Sanitary Sewers (Alternative T)

This plan was not given further consideration because of: the cost, estimated by Chicago to be $4,466,500,000; the disruption of traffic and other municipal service; and ineffectiveness, because sewer separation would not reduce pollution of the waterways from surface runoff, and would not provide for flood control.

4.1.3 The No-Action Alternative

The short- and long-term environmental impacts of allowing existing wastewater conditions to continue are discussed in the following sections. The purpose is to compare the impacts assessed for each proposed plan with the consequences of a "no-action" course. The negative and/or beneficial impacts of the no-action alternative on the Chicago metropolitan area fall under five environmental categories: water quality, water supply, water management goals, flooding and backflow, and financial resources.

(1) Water Quality

The water quality of the Chicago area's waterways will continue to deteriorate as combined-sewer overflows become more frequent and more concentrated with pollutants. As land development and population increase, so will sewage discharges, and dilution-water from Lake Michigan will have to be drawn to lower pollutant concentrations to meet present water quality standards. Lake Michigan flow regulations limit dilution-water discharges to 3,200 cfs. This allowable flow rate is not sufficient to dilute pollutant levels to water quality standards.

Urban runoff containing combined sewage overflow will continue to increase in volume with land development and population growth. In Lake Michigan and the inland waterways, water quality will be degraded to severe levels by this runoff. Some of the pollutants commonly associated with urban/sewage runoff include: ammonium compounds, suspended solids (SS), biochemical oxygen demanding compounds (BOD), oils, grease, organic and inorganic fertilizers, pesticides, solvents, herbicides, and coliform.

(2) Water Supply

Lake Michigan is presently a water supply resource for Cook County. If additional water is drawn from the lake for dilution purposes, the supply may be temporarily threatened, and other water supply resources will have to be explored. The critical demands for Lake Michigan as a water supply, however, presently take precedence over the demand for it as dilution water. The possibility of altering the established discharge regulation is slight while water pollution problems persist.

Groundwater is another water supply resource which will be depleted eventually. Piezometric or hydraulic pressure levels of certain aquifers are already reduced, and further pumping will limit the use of these aquifers as a viable supply.

(3) Water Management Goals

The Federal Water Pollution Control Act Amendments of 1972, PL 92-500, have established goals for maintaining or improving the water quality of the Nation's surface water systems. PL 92-500 states that pollutant discharge sources must be eliminated by 1983 and, wherever attainable, interim water quality standards must be met by 1977 to protect and propagate fish, shellfish, and wildlife, as well as to provide for water recreation. These goals will not be achieved in the combined-sewer service area of Greater Chicago even when existing dischargers meet current Federal and state effluent requirements.

(4) Flooding and Backflow

Flooding frequency within the combined-sewer service area and backflows to Lake Michigan will also increase as the area grows in population and develops. Damages to shorelines, personal property, public thoroughfares, and businesses will increase at a rate greater than that of flooding frequency, and the impact will be more severe than before. Backflows, carrying combined-sewer overflow pollutants, will increase in volume and frequency and will further pollute Lake Michigan.

(5) Financial Resources

The only beneficial impact of the no-action alternative on the community is in the area of taxes. Tax assessments for water and sewer use will increase by approximately 10 to 15 percent as a result of implementing any of the alternative plans. For example, a maximum of one-third of the costs projected for implementing Phase I, the tunnel system phase of the Tunnel and Reservoir plan, could be funded by the local property taxes since Federal and state funds might cover only two-thirds of the project costs. Normal tax rate increases can be expected if the no-action alternative is implemented.

4.2 ALTERNATIVE PLAN MODIFICATIONS

The Flood Control Coordinating Committee (FCCC) modified each of the remaining 17 alternative plans so that they would achieve uniformly the project objectives, thus, eliminating complex weighting factors and allowing immediate direct comparison of alternatives. The committee applied four collection storage levels (MODS) to each of the alternative plans. This section addresses the MODS (modifications) or subsystems of the plans developed by the FCCC in the following sections:

- Description of Subsystems
- Evaluation and Comparison
- Recommendations and Further Studies
- Plan Selection.

4.2.1 Description of Modifications

The subsystems or MODS, as developed by the FCCC and evaluated in detail by the FCCC's technical advisory committee, are described as follows:

- MOD 1 is the original plan, as proposed by the author, in which the storage volume differs significantly from the other plans.

- MOD 2 provides a system storage capacity of 118,000 acre-feet (ac-ft) to contain the largest storm event of record.

- MOD 3 provides a storage capacity of 50,000 ac-ft to prevent backflow to Lake Michigan without improvements to existing waterways.

- MOD 4 adds a storage volume of 20,000 ac-ft to the plan to collect a worst-storm rainfall which has a recurrence interval of one year, and includes waterway improvements to prevent backflow to Lake Michigan for all storms recorded to date.

The estimated storage volumes for MODS 2, 3, and 4 were based on precipitation data collected during a 21-year period (1949 to 1969). The largest storms of record occurred during this period and were considered in the storage volume estimations. To maintain consistency in the evaluation and comparison of alternatives, a computer program incorporated the features of each MOD in each alternative. MOD's 2, 3, and 4 were the only modifications applied to each alternative plan in this computational effort. MOD 1 was eliminated from further consideration because it represents the original proposed plan, which did not meet the established overall objectives of the program. Some of the MOD 1 or original plan features, however, have been incorporated in MOD's 2, 3, and 4.

4.2.2 Evaluation and Comparison of Modified Plans

The evaluation and comparison of the 51 subsystems (17 plans with 3 modifications each) was based on 8 principal factors, all of which were given equal weight in the next step. The parameters, for which values were estimated, included: present worth (1972) capital costs, expected annual operating and maintenance costs (1972 value), project benefits, land acquisition acreage, underground easement acreage, resident and business relocations, overall construction environmental impacts, and overall operation environmental impacts. For the purpose of comparing the alternatives, Table IV-1 presents a matrix of the factors and the modified plans under each MOD category. The derivation of the values indicated in the table and the rationale used in the evaluation, are summarized in the following sections.[1]

(1) Capital Costs and Annual Costs

The capital cost and equivalent annual cost figures shown in Table IV-1 under each alternative, were calculated on a present worth basis as of 1972. The total equivalent annual costs include estimates calculated for the project, operation, maintenance, equipment replacement, and power sales, with the latter treated as a negative benefit (a benefit which will cause an impact on existing conditions).

A present worth analysis was performed to determine, on a comparative basis, one-time construction cost factors and continuing operation, maintenance, replacement, and benefit factors. A preliminary construction schedule for the pertinent phases of the flood control and pollution abatement program was developed for the 10-year period from 1972 to 1982, and taken into consideration in the analysis.

For the economic analysis, a discount rate of 7 percent was used, and all costs and benefits were based on 1971 price levels that were accumulated to 1972. The project life selected for the purpose of financial analysis is 50 years and covers the period of 1972 to 2022. No charges were specifically included in the analyses which reflect interest during

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[1] The Flood Control Coordinating Committee, August 1972.

Table IV-1
Alternative Plan Comparison Matrix

ALTERNATIVE PLANS	MOD 2								MOD 3								MOD 4*							
	Capital Costs (1972) (10^6 dollars)	Equiv. Annual Costs (1972) (10^6 dollars)	Equiv. Annual Tangible Benefits (10^6 dollars)	Benefit - Cost Ratio **	Land Acquisition (Acres)	Underground Easement (Acres)	Resident and Business Relocations	Overall Environmental Impacts	Capital Costs (1972) (10^6 dollars)	Equiv. Annual Costs (1972) (10^6 dollars)	Equiv. Annual Tangible Benefits (10^6 dollars)	Benefit - Cost Ratio **	Land Acquisition (Acres)	Underground Easement (Acres)	Resident and Business Relocations	Overall Environmental Impacts	Capital Costs (1972) (10^6 dollars)	Equiv. Annual Costs (1972) (10^6 dollars)	Equiv. Annual Tangible Benefits (10^6 dollars)	Benefit - Cost Ratio **	Land Acquisition (Acres)	Underground Easement (Acres)	Resident and Business Relocations	Overall Environmental Impacts
A***	2815	239	47	0.56	400	2000	Low	(See parts (4) and (5) of Section 4.1.3)	1621	148	46	0.57	300	300	Low	(See parts (4) and (5) of Section 4.1.3)	1804	150	57	0.77	0	1000	Low	(See parts (4) and (5) of Section 4.1.3)
Ap	3137	223	47	0.60	2000	3200	Med.		1957	139	44	0.61	1100	1900	Med.		—	—	—	—	—	—	—	
B	2211	194	47	0.69	600	1600	Low		1360	129	46	0.66	400	300	Low		1533	129	57	0.89	0	1000	Low	
Bp	2523	182	47	0.73	1800	3400	Med.		1637	120	44	0.71	1200	2000	Med.		—	—	—	—	—	—	—	
C	2183	193	47	0.69	1100	1800	High		1380	129	46	0.66	400	700	Low		1484	124	57	0.93	0	1000	Low	
Cp	2491	179	47	0.74	2000	3600	High		1676	121	44	0.70	1400	2100	High		—	—	—	—	—	—	—	
D	2680	243	43	0.55	5000	0	High		1589	159	44	0.54	3600	0	High		1532	146	57	0.79	2500	0	High	
E	2071	183	47	0.73	800	1600	Med.		1401	129	46	0.66	500	500	Med.		1470	122	57	0.94	100	1000	Med.	
F	3615	294	47	0.45	1600	0	Low		1834	156	44	0.55	1100	0	Low		1530	124	57	0.93	200	0	Low	
G	1923	162	47	0.82	600	0	Low		1002	90	44	0.94	400	0	Low		1377	115	57	1.00	200	0	Low	
H	1557	137	47	0.97	800	0	Low		912	85	44	1.00	400	0	Low		1356	115	57	1.00	400	0	Low	
J	1554	138	47	0.96	600	0	Low		921	86	44	0.99	400	0	Low		1366	116	57	0.99	400	0	Low	
Q	1551	138	47	0.96	1300	400	High		1014	97	44	0.88	500	500	Med.		1367	118	57	0.97	400	200	Med.	
Qp	1583	133	47	1.00	700	700	High		1070	93	44	0.91	500	400	High		—	—	—	—	—	—	—	
R	1580	149	47	0.89	800	300	Med.		1040	103	46	0.82	500	100	Med.		1363	120	57	0.96	200	300	Med.	
Rp	1894	157	47	0.85	900	1200	High		1195	103	44	0.82	600	700	High		—	—	—	—	—	—	—	
S	1843	157	47	0.85	800	0	Med.		979	89	44	0.95	500	0	Med.		1346	115	57	1.00	200	0	Med.	

* Considered not economically feasible for Alternative Ap, Bp, Cp, Qp, and Rp.

** A policy decision was made to control flooding and waterway pollution in the Chicago metropolitan area. Since this public policy has been established, the assumption is that the least cost plan for fulfilling the policy is justified and that the benefits of the project to the public are equal to the least costly alternative in each MOD. The benefit-cost ratio, therefore, was calculated based on this assumption.

*** FCCC designations.

construction. In addition, the costs and benefits were not escalated to reflect inflation.

(2) Tangible Benefits

The cost studies previously described were made to determine the most economical plan which would comply with established pollution standards, as well as provide flood control for the several surface waterways without releasing flood waters into Lake Michigan. Since this public policy has been established, the least cost project for fulfilling the policy is assumed to be justified and the benefits of the project to the public are equal to project costs. Some of these benefits are tangible and can be quantified, while other intangible benefits cannot. Benefit analyses were performed to determine whether appreciable differences in the tangible, quantifiable benefits exist among project schemes.

Monetary values for some of the tangible benefits were assigned to determine whether the benefits effected the relative desirability of the alternatives evaluated. Benefits for pumped-storage power generation differed from surface transport and navigation in alternatives. However, benefits for recreation and land enhancement, and flood damage alleviation were essentially equal to all alternatives. The revenues from pumped-storage power generation were considered to increase total project costs. Benefits for navigation and surface transport are applicable only for the MOD 4 alternatives, as shown in Table IV-1. The incremental navigation benefit, expressed as an equivalent annual value, is approximately $15.0 million per year and is less than the cost increment between the MOD 3 and 4 alternatives, which is approximately $30.0 million (see Alternative H). The benefits, therefore, are nearly equal for all schemes of a given MOD and do not significantly affect alternative selections.

(3) Acquisition, Easements, and Relocations

The tax base is normally reduced when land is transferred from private ownership to public ownership. For several alternative plans, land requirements for either surface or underground easements do not apply since the land is already publicly owned.

The purchase of land for surface reservoirs, holding basins, pits or quarries, and the extensive easements required for mined storage chambers may result in costly delays. Land and underground easement acquisition, therefore, is an important consideration in the evaluating alternatives. Many of the alternatives will not require displacement of homes or businesses. Alternatives with surface reservoirs or holding basins located in densely populated or developed areas, are expected to have a significant relocation impact.

(4) Construction Environmental Impacts

Construction activities of each alternative are expected to have localized effects on the environment. These effects may include such impacts as: traffic disruptions, navigation disruption, fugitive dust emissions, and higher noise levels. Construction activity will cause relatively short-term impacts, and these changes are not irreversible. Thus, areas can be restored and used.

Rock and spoil disposal is expected to be a major problem with most of the alternatives. Alternatives which will produce large quantities of rock and spoil will require either land or water disposal sites. Rock may be stockpiled and sold commercially, used as fill, or used to develop winter recreational areas. Rock and spoil material is considered "clean" and treatment or refining will not be required.

Fugitive dust emissions resulting from quarry excavations, surface reservoir dike construction, and other rock handling operations must employ proper construction techniques to minimize dust problems.

Vehicle traffic is not expected to be interrupted significantly. However, in a few locations near dropshafts, some disruption will be unavoidable. The separation of combined-sewers into separate storm and sanitary sewers, (Alternative T), may cause a major impact on the environment. Excavation of many streets is required to implement this alternative. This will result in traffic noise and other disruptions over most of the project area throughout the construction phase of the project.

Most alternatives are expected to be located underground in industrial areas. Disruptions caused by construction activities will most likely be minimal. For example, noise will be minimal and, if necessary, current noise abatement technology can be applied.

Disruptions to navigation are expected to occur in all MOD 4 alternatives which require increased depth and channel width in the Calumet-Sag Channel and the Chicago Sanitary and Ship Canal. The impact is unavoidable and measures to mitigate this impact are limited. The other alternatives do not require waterway improvement.

(5) Operation Environmental Impacts

The environmental impacts of each alternative will most likely be minimal, since many of the systems will be located underground. Surface systems will be on land zoned for industrial use. Quarries are presently surrounded by undeveloped land barriers, which will minimize noise and adverse aesthetic effects. Since surface reservoirs occupy relatively large tracts of land, the structure should be designed to be aesthetically acceptable.

Odor may become an operational problem, and a properly operated facultative lagoon will be necessary for each quarried pit or surface reservoir. All pits and surface reservoirs will most likely require mechanical aeration equipment, which oxidizes the odor-causing organic matter contained in the combined-sewer wastewater.

Conveyance tunnels and mined storage subsystems specified in various alternative plans will be located in the Niagaran and Galena geologic formations, about 300 and 800 feet below ground surface, respectively. The level of the groundwater aquifer in the Niagaran formation is above the proposed tunnels in most places, and infiltration of groundwater into the tunnels will result. The water flow will be at a sufficiently high rate, however, to eliminate the probability of aquifer pollution. The amount of water infiltrating the tunnels is expected to be small in relation to the total aquifer supply, and no adverse effects on the long-term water supply will occur. In overdeveloped areas (e.g., McCook) where the upper aquifer water levels are low, the aquifer can be recharged to prevent exfiltration of polluted water from tunnel and reservoir subsystems. Groundwater levels in the Galena formation will be above proposed mined storage cavities in most of the planned locations. Groundwater inflow is not expected in these areas because the piezometric (hydraulic pressure) level is lowered annually about 13 feet due to overdevelopment. Costs for an artificial recharge well system have been included in each alternative. This system would prevent leakage of polluted water into the aquifers. The recharge water quality specifications will comply with present drinking water standards, and the mineral content will not exceed natural groundwater concentrations. Thus, the overall quality of the groundwater will be protected.

Alternative D is the only plan that may affect wildlife and vegetation in the Chicago metropolitan area. If excavated rock and spoil material is discarded adjacent to the canals, some habitats may be permanently damaged. Transporting the material to a disposal site away from existing waterways will mitigate this effect.

Fish species are not expected to be affected adversely during overflow periods. The DO level during dry weather, the high temperatures during the summer, and the ammonia-nitrogen levels in the restricted waterways have limited the variety of fish. In nonrestricted waterways, warm water biota and native game fish are also not adversely affected by short-term oxygen depletion during overflows.

Existing and planned recreational lands adjacent to waterways will be enhanced by any of the alternative plans. Swimming, boating, and fishing may be allowed in waterways which presently are restricted because of poor water quality.

In summary, the results of the comparative analyses are as follows:

- Land enhancement. All alternatives will meet specified water quality standards; land enhancement of the recreational resources of the region will be similar for all alternatives.

- Overbank flooding. All alternatives will eliminate backflows to Lake Michigan, will reduce the frequency and severity of overbank flooding and basement flooding adjacent to the waterways, and will improve movement in the waterway systems.

- Land. The amount of land needed for construction of works is different for each alternative.
- Sewer service benefits. A system of tunnels will reduce the cost of auxiliary outlet sewers; benefits would be attributable to MOD's 2 and 3 and, due to small storage capacity, no benefits for improved sewer service would be credited to MOD 4 projects.
- Water supply. Alternatives which include major project features sited in the underground aquifer systems, will include recharge systems for aquifer protection.
- Navigation and surface traffic. Benefits from navigation and surface traffic are limited to MOD 4 for all alternative projects; the estimated equivalent annual benefit accruing to these projects is $15 million.
- Other factors. Flexibility of phasing, expansion, and construction were considered in the evaluation.

4.2.3 Recommendations and Further Studies

A technical advisory committee was organized by the FCCC to prepare a detailed report on the proposed alternative plans. The committee issued an interim report, entitled "Evaluation Report of Alternative Systems," which the FCCC reviewed and then unanimously agreed that the final plan for flood and pollution control in the Chicago metropolitan area "...should be in the form of the Chicago Underflow plan (Alternatives G, H, J, and S) with MOD 3 level of storage. These alternatives are less costly and more environmentally acceptable to the community than any of the other plans presented. Detail studies along the lines of these alternatives should proceed to develop the final plan layout."

The advisory committee presented the MOD 3 reservoir storage level of 50,000 ac-ft in the interim report and recommended to the FCCC the adoption of the MOD 3 subsystem. The committee concluded that the modification will:

- Provide flood protection for the recurrence of the heaviest storms of record without the need of releasing flood waters to Lake Michigan

- Capture the combined-sewer overflows and provide subsequent treatment before discharging this water to the waterways, for all but the largest storms of record (99.7 percent BOD eliminated)

- Overflow a substantial quantity of water only during a recurrence of the three worst storms of record

- Reduce overflow events so that fish and other aquatic life will not be harmed by short-term DO depletion

- Provide the least costly plan, as compared to the MOD 2 and MOD 4 plans, with the least disruption to the urban community.

In August 1972, the FCCC published a report[1] presenting a final recommendation. The report, including seven technical appendices, recommended a consolidation of Alternatives G, H, J, and S, which ultimately resulted in the Tunnel and Reservoir Plan (TARP). The committee then initiated a detailed environmental assessment study to compare TARP with five selected alternatives, including the "no-action" alternative. Alternatives A_p, D, E, and F were selected based on the previous comparative analysis (see Section 4.2.2). Fifteen environmental parameters and five regional goal factors were identified as significant impact items. The impacts on these parameters and factors and the implications of the "no-action" alternative were assessed to determine the degree to which each alternative met the overall project objectives. Table IV-2 summarizes the results of this assessment. The final plan selection, which was revealed in a detailed report,[2] was based on this assessment.

4.2.4 Plan Selection

The results of the detailed assessment of the six selected alternatives showed negative construction impacts for all alternatives. In four of the alternatives, the impacts range

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[1] Flood Control Coordinating Committee, August 1972.

[2] Metropolitan Sanitary District of Greater Chicago, "Environmental Assessment of Alternative Management Plans for Control of Flood and Pollution Problems Due to Combined-Sewer Discharges in the General Service Area of the MSDGC," November 1973.

Table IV-2
Summary of Detailed Assessment[1] (Ranking)

ALTERNATIVES	WATER						LAND				AIR			RESOURCES						REGIONAL GOALS						Overall Rank
	Water Quality	Urban Flooding	Water Supply	Flow Regulation	Sedimentation	Category Rank	Land Use	Land Reclamation	Geology	Category Rank	Air Quality	Noise Vibrations	Category Rank	Human	Mineral	Energy	Technological	Transportation	Category Rank	Economic	Aesthetic	Recreational	Ecosystems	Health & Safety	Category Rank	
No Action	6	6	6	6	6	6	5	5	NA	5	NA	NA	-	5	NA	NA	NA	6	6	6	6	6	6	6	6	6
Ap	*	*	*	*	*	*	*	*	*	*	1	*	2	1	*	5	*	*	4	*	*	*	*	*	*	2
D	*	*	*	*	5	5	6	6	*	6	5	1	1	6	6	1	5	5	5	*	5	5	5	5	5	5
E	*	*	*	*	*	*	*	*	*	*	*	2	3	2	*	4	*	*	*	*	*	*	*	*	*	4
F	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	3	1	*	3	*	*	*	*	*	*	3
Tun-Res	*	*	*	1	*	1	*	1	*	1	*	*	*	*	1	2	*	*	*	*	*	*	*	*	*	1

* Shares equal rank with other alternatives

NA Not applicable

[1] A point system method was used in the original assessment in which the magnitude of the impact was measured on a scale of 0 to 3 with 0 indicating no effect and 3 indicating highest effect. Negative impacts were indicated with a minus (-) and beneficial impacts with a plus (+) in the original study.

from negative to beneficial, depending on whether rock and overburden are disposed on-site, in a nearby landfill site, or used in one of the proposed Lake Michigan landfill developments (e.g., lakefront peninsulas or islands and the central area air-rights development). If the material is utilized in lakefront development and conveyed by a tunnel system, construction impacts will probably be beneficial for any of the alternatives evaluated. Other negative construction impacts may include: localized degradation of air quality, construction and traffic noise, construction-related vibrations, energy consumption, and traffic congestion. The magnitude of these impacts will cover a wide range, depending on what abatement procedures will be routinely applied, as well as on what construction procedures will be used. Overall, the alternatives with more subsurface systems will have less construction impact than surface-system-oriented alternatives.

The short-term and long-term impacts assessed for each alternative will be beneficial. Alternative D ranks lowest in this respect, primarily because of the plan's surface reservoir feature which will cause a substantial negative impact on adjacent land uses. Although Alternatives A_p, E, and F, which were given a rank in the assessment analysis, are essentially equal with respect to short-term and long-term impacts. They will achieve overall project objectives on a nearly equal basis.

TARP ranks slightly higher than the other alternatives with respect to construction, short-term, and long-term impacts. The plan's greater reservoir capacity reduces the untreated overflows to waterways. In addition, the plan ranks high in short-term land reclamation because existing sludge beds will be removed.

In summary, the FCCC concluded and stated that very few negative impacts are expected for any of the alternatives with tunnels, and adverse impacts will occur if the "no-action" alternative is selected. The negative impacts of construction activities on the environment will most likely be transitory, relatively short-term, and localized, regardless of alternative. Finally, the beneficial impacts of Alternatives Ap, D, E, F, or TARP will far exceed the negative impacts. Within the scope of the analysis, TARP has the highest ranking and was, therefore, selected as the most suitable plan to solve the flood and pollution problems of the Chicago metropolitan area.

4.3 WASTE DISPOSAL ALTERNATIVES

Construction and operation of the tunnel system will generate waste materials that must be disposed of in an environmentally sound manner. The large volumes of spoil material generated during tunnel excavation should be removed from the tunnel and conveyed to waste treatment facilities. Drainage flow through the tunnels from groundwater infiltration and from grouting operations should be treated at appropriate facilities before discharging into existing waterways. Wastes generated during normal operation of the tunnels will consist largely of sludge solids which would impede proper operation of the tunnel's system if the material is not removed.

The available alternatives for disposal of these wastes and the estimated cost of required disposal operations, are discussed in the following sections.

4.3.1 Drainage Flow From Tunnel Construction

Inflows of groundwater during tunnel construction and operation can be expected, especially in fault zones and places where the groundwater table is high. Where infiltration is high, grouting operations will be carried out to limit the flow to approximately normal sewer infiltration levels (roughly 500 gallons per inch of tunnel diameter per mile/per day). Water from the grouting operation will add little to the tunnel drainage flow. Maximum flow expected in the Phase I Mainstream Tunnel from 59th Street to Addison Street will peak at about 3.83 MGD over the length of the tunnel due largely to groundwater infiltration.

Current MSDGC construction specifications require holding effluent from tunnel dewatering until most of the rock, mud, grout material, and other solids settle. A turbidity test should be performed to determine the extent of settling. The specifications further require the tunnel contractor to dispose of settled solids in an environmentally safe manner.

Should further treatment be necessary, drainage flow could be pumped from the construction shaft to the nearest treatment plant. However, the anticipated quality of the infiltrating water is such that necessary treatment beyond settling is unlikely. The 3.83 MGD maximum drainage flow represents less than one-half of one percent of the average flow through the West-Southwest plant. For this reason, the cost of treating the drainage flow is most likely a minor factor in deciding the proper disposal method for tunnel drainage. For settled solids, the waste material could be conveyed to the appropriate waste treatment facilities for processing. This waste will contain deleterious substances such as: concrete particles, grout waste, and other construction waste material. Another alternative for the settled solids is to transport the material to approved disposal sites.

4.3.2 Ultimate Disposal of Sludge

The capture of combined-sewer overflows during storm events will require the eventual disposal of sludge solids flushed into the tunnels. Several alternatives are available for the disposal of sludge solids captured by the tunnel system and conveyed to the West-Southwest plant for treatment. The major options open to the MSDGC presently are:

- Land reclamation program in Fulton County
- NuEarth program
- Sludge sales to a broker as fertilizer
- Sanitary landfill
- Incineration with landfilling of ash residue.

These alternatives are discussed more fully in the sections below.

(1) Land Reclamation Program in Fulton County

The application of stabilized sludge to soil as a fertilizer in either liquid or solid form completes the recycling of the waste products. The MSDGC currently practices spreading of stabilized sludge on strip-mined land in Fulton County, Illinois. Reintroducing organic material to the depleted soil by recycling sludge has been shown to be effective for land reclamation. The MSDGC is still researching various aspects of land application of sludge including rates and methods of application and rates of vegetation uptake for various elements. The basics of the program are well established and understood, however.

At the Fulton County site, a monitoring program samples soil, plant, and runoff components of the ecological cycle for the presence of various elements and compounds. Agricultural crops are regularly sampled for nitrogen and heavy metal concentrations. Also, runoff from the area is tested for compliance with applicable standards. The MSDGC is capable of recycling the runoff if water quality is found to be unacceptable.

(2) NuEarth Program

The MSDGC currently makes available air-dried sludge from its West-Southwest treatment plant for area residents to use as fertilizer for gardens. Air-drying of digested sludge is done by spreading it on sandbeds for about two weeks, which dewaters the sludge so it can be bagged as fertilizer. The positive initial public response indicates that this method of recycling wastes may find long-term acceptance. Unfortunately, climatic factors limit the use of this method of sludge disposal to approximately eight months of the year.

(3) Sale of Sludge to Brokers for Fertilizer

Sludge that has been dried under heaters, retains a higher nitrogen content than digested sludge and makes an acceptable soil-builder and fertilizer. Heat-dried sludge is sold by the MSDGC to a broker who sells it as fertilizer, so that a portion of the cost of drying the sludge is recovered. This process constitutes a significant means of sludge disposal for the MSDGC. Costs of various disposal options are compared later in this section.

(4) Sanitary Landfill

Placing digested sludge in a sanitary landfill is another approved method of sludge disposal. Wastes placed in a landfill are covered at the end of each day with a layer of soil so that potential contaminents are sealed up each day in a "cell". Precautions are taken to protect groundwater supplies from contamination by leachate near the disposal site. This is usually done by installing a drainage collection system beneath the site. Also, gases generated in the waste decomposition must be dispersed to eliminate the possibility of an explosion.

The MSDGC plans to utilize sanitary landfills as one component of its sludge disposal program. In so doing, they will adhere to land disposal practices recommended by EPA.[1]

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[1] Brunner, D.R., and Keller, D.J., "Sanitary Landfill Design and Operation," U.S. EPA, Washington, D.C., 1972.

(5) Incineration With Landfilling of Ash Residue

Incineration of raw sludge reduces substantially the volume of material that must ultimately be disposed of. The combustion process converts the volatile fraction of the sludge solids largely to carbon dioxide and water vapor, leaving the nonvolatile component for landfill disposal, which comprises about 30 percent of total sludge solids.

Incineration was a relatively inexpensive means of reducing the volume of sludge to be disposed of until the advent of strict air pollution regulations. Requirements to add costly emission control devices have caused many municipal incinerators across the country to close down. Chicago is presently an air quality management area (AQMA) and compliance with established ambient air quality standards is required.

Landfill disposal of ash residue is subject to the same restrictions that cover land disposal of digested sludge.

* * * *

Disposal costs have been developed by the MSDGC for sludge produced at the West-Southwest facility, including sludge from the TARP Mainstream Tunnel operation, for various combinations of the disposal alternatives identified above. The cost analysis of sludge disposal systems presented here does not include a discussion of alternative sludge stabilization systems examined by the MSDGC for the West-Southwest Treatment Plant. The interested reader is referred to the MSDGC "Facilities Planning Study - Overview Report" for detailed descriptions of these alternatives and their potential interfaces with the various disposal schemes.

By the year 2000, the MSDGC expects the West-Southwest plant to be processing an average of 1,236 tons of sludge daily (dry weight), including the tonnage contributed by the TARP Mainstream and Des Plaines tunnels. Sludge collected by TARP is expected to contribute about 25 percent of the volume handled by the West-Southwest facility. Since using certain stabilization processes, such as anaerobic digestion, can reduce the amount of sludge to be disposed of, disposal costs are presented in terms of the actual volumes of sludge to be handled. These costs are:

- Disposal of total sludge load in a sanitary landfill:

  Sludge volume: 991 dry tons/day (dt/d)
  Planning period: 25 years
  Total cost: $176,703,600
  Annual costs:
    Capital: $ 1,122,300/year
    M&O: $12,536,100/year
    Total: $13,658,400/year

- Disposal of total sludge load by land application as dry fertilizer:

  Sludge volume: 991 dt/d
  Planning period: 25 years
  Total cost: $416,354,000
  Annual costs:
    Capital: $ 9,345,000/year
    M&O: $22,705,700/year
    Total: $32,050,700 (Max.)[*]
    $29,682,800 (Min.)[†]

- Disposal of total sludge load by land application of liquid fertilizer:

  Sludge volume: 991 dt/d
  Planning period: 25 years
  Total cost: $348,822,400
  Annual costs:
    Capital: $ 5,948,800/year
    M&O: $21,015,400/year
    Total: $26,964,200/year

- Disposal of total sludge load by sale to broker as fertilizer after heat-drying:

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[*] Max.: assuming truck transportation of sludge 200 miles to Fulton County site.

[†] Min.: assuming rail transportation of sludge 200 miles to Fulton County site.

Sludge volume: 1,236 dt/d
Planning period: 25 years
Total cost: $212,708,900
Annual costs:
    Capital: $ 2,626,000/year
    M&O: $ 13,815,200/year
    Total: $16,441,200/year

- Disposal of total sludge load by incineration and landfilling of ash residue:

  Sludge volume: 1,236 dt/d
  Planning period: 25 years
  Total cost: $161,306,200
  Annual costs:
      Capital: $ 2,547,000/year
      M&O: $ 9,914,100/year
      Total $12,461,100/year

- Disposal of 781 dt/d by landfill and 455 dt/d by sale to broker as fertilizer:

  Sludge volume: 1,236 dt/d
  Planning period: 25 years
  Total cost: $216,432,600
  Annual costs:
      Capital: $ 2,186,600/year
      M&O: $14,497,900/year
      Total: $16,684,500/year

- Disposal of 781 dt/d by land application as dry fertilizer and 455 dt/d by sale to broker as fertilizer:

  Sludge volume: 1,236 dt/d
  Planning period: 25 years
  Total cost: $329,240,400
  Annual costs:
      Capital: $ 5,735,300/year
      M&O: $19,676,400/year
      Total: $25,411,700/year

- Disposal of 439 dt/d by land application as liquid fertilizer, 127 dt/d by sanitary landfill, 93 dt/d by NuEarth distribution, and 346 dt/d by sale to broker:

Sludge volume: 1,005 dt/d
Planning period: 25 years
Total cost: $280,480,900
Annual costs:
    Capital: $ 1,290,100/year
    M&O: $20,391,200/year
    Total: $21,681,300/year

4.3.3 Spoil Material

For the ten-year construction period, excavation of the Phase I TARP tunnels will produce a solid measure of approximately 11,747,000 cubic yards (roughly 26 million tons) of earth and rock that must be disposed of in an environmentally acceptable fashion. For comparison purposes, the total solid measure of spoil produced by the construction of TARP (including reservoirs) is 183 million cubic yards. Peak spoil production from tunnel excavation is expected to be approximately 2.2 million cubic yards (4.9 million tons) at the midpoint of the ten-year construction period. Construction of the Mainstream Tunnel from 59th Street to Addison Street will account for approximately 3,027,000 cubic yards of spoil material (-6,743,000 tons) including excavation of the pumping station at 59th Street. The duration of constructing this segment is approximately 6.5 years. MSDGC has indicated that disposal of the excavated spoil material will be the responsibility of the construction contractor for each tunnel section. Since each contractor's proposed disposal plan and criteria will not be identified until the preconstruction meetings with the MSDGC, we present here only those alternatives most likely to be implemented by the contractors. These disposal options are:

- Sale of spoil to quarry operators
- Throw-away to operating quarries
- Disposal in defunct quarries
- Sale to other parties.

These alternatives will be discussed briefly in the following sections:

(1) Sale of Spoil to Quarry Operators

Direct sale of the marketable portion of excavated material to the operators of area quarries may be an alternative method for disposing of a small portion of the tunnel rock. The large portion of the excavated material will be low grade rock spoil usable only as select fill for such uses as road base material and site grading. Although such applications are not typical of the uses of materials currently extracted from area quarries, quarry operators may be receptive to marketing the low grade material.

Two major quarries are actively operating in the metropolitan area: the McCook quarry operated by Vulcan Materials, Inc. and the Thornton quarry operated by Material Service, Inc. These quarries currently furnish approximately 5,000,000 cubic yards per year of dolomitic rock. This rock is used mostly as concrete aggregate. Some of the material is used as select fill material by the area's construction industry.

(2) Throw-Away to Operating Quarries

In exercising this option, the contractor would merely transport the spoil to either McCook or Thornton quarries, and provide the material free for subsequent sale by the quarry operators. This action would discharge the contractor's obligation to dispose of the material in an environmentally acceptable manner although it would not enable the contractor to defray his transportation costs through sale of the spoil.

(3) Spoil Disposal in Defunct Quarries

Disposal of nonsaleable spoil in the defunct Stearns quarry is attractive because of the possibility of upgrading land use in that area. The quarry has a capacity of about 6.5 million cubic yards to street grade. Once filled to this grade, the site could be designated for recreational or other valuable land uses because of its central location.

(4) Sale to Other Parties

Contractors may find it to their advantage to sell some portion of the spoil products to users other than the quarry operators. This is expected to be an acceptable disposal alternative because of the existing system of permits and licenses regulating uses of spoil material. The permit system, enforced by the city of Chicago, has been effective in avoiding abusive disposal practices in previous tunnel projects.

V. DESCRIPTION OF THE PROPOSED ACTION

V. DESCRIPTION OF THE PROPOSED ACTION

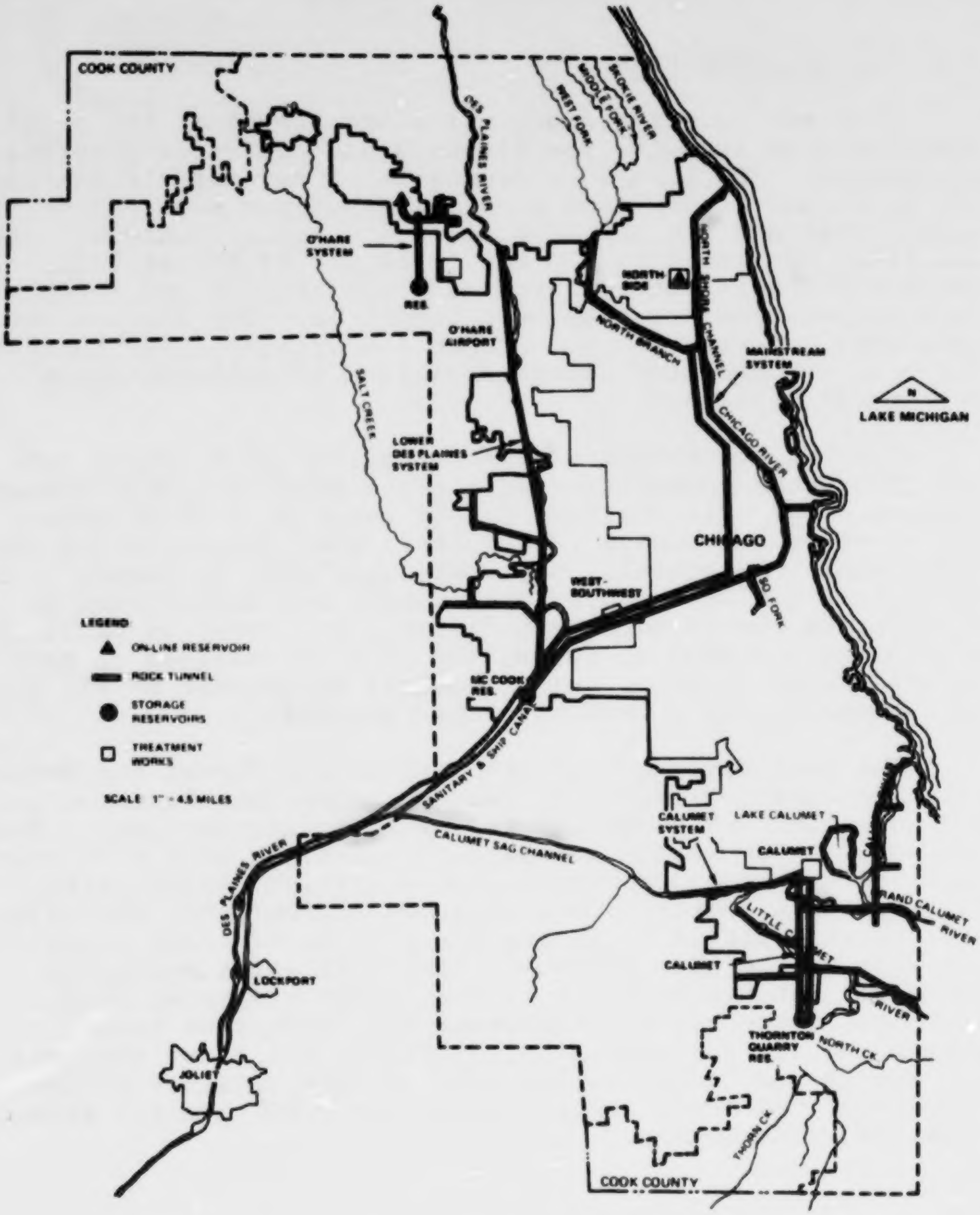
5.1 THE SELECTED PLAN

TARP was selected among all alternatives as the most feasible plan to solve the flooding and pollution problems of Chicago. The plan is a composite of several alternatives (G, H, J, and S) modified to provide optimum benefits for the lowest cost and minimum adverse environmental impacts. TARP was first described in the FCCC's report of August 1972. Refinements were incorporated as field studies and subsurface exploration programs were completed. The studies and programs, however, did not change the original TARP concept, but only incorporated design revisions to optimize overall system effectiveness.

TARP was developed to enable collection of storm runoff from urban communities within the MSDGC's combined-sewer service area. The polluted runoff water will be diverted and conveyed to storage reservoirs. When favorable dry weather conditions prevail, the wastewater will be pumped from the reservoirs into conveyance tunnels and transported to appropriate sewage treatment facilities. Based on rainfall records of the past 21 years, the plan is designed to have the capability of handling runoff volumes equivalent to all except three of the severest storms recorded.

The four systems that are part of the Tunnel and Reservoir Plan are: Mainstream, Calumet, Lower Des Plaines, and O'Hare, which are described in the following sections. Each system is a completely independent operating unit with collection, storage, conveyance, and treatment capabilities. Although this chapter summarizes the entire TARP, the objective of this EIS is to assess the effects of those tunneling portions of the plan directly related to water pollution control. For the purposes of the impact analysis, this statement describes and evaluates the conveyance tunnel system and its subsystems only. Figure V-1 shows the present routes and layout of the TARP systems relative to the MSDGC combined-sewer service area, the MSDGC overall service area, and Cook County.

FIGURE V-1
Tunnel and Reservoir Plan
System Layout and Routes


COOK COUNTY
DES PLAINES RIVER
WEST FORK
MIDDLE FORK
SKOKIE RIVER
O'HARE SYSTEM
RES.
O'HARE AIRPORT
NORTH SIDE
NORTH SHORE CHANNEL
NORTH BRANCH
MAINSTREAM SYSTEM
LAKE MICHIGAN
N
SALT CREEK
LOWER DES PLAINES SYSTEM
CHICAGO RIVER
CHICAGO
WEST-SOUTHWEST
SO. FORK
LEGEND
▲ ON-LINE RESERVOIR
ROCK TUNNEL
● STORAGE RESERVOIRS
□ TREATMENT WORKS
SCALE 1" = 4.5 MILES
MC COOK RES.
SANITARY & SHIP CANAL
CALUMET SYSTEM
LAKE CALUMET
CALUMET
CALUMET SAG CHANNEL
DES PLAINES RIVER
GRAND CALUMET RIVER
LITTLE CALUMET
CALUMET
RIVER
LOCKPORT
THORNTON QUARRY RES.
NORTH CK
JOLIET
THORN CK
COOK COUNTY

5.1.1 TARP Systems

Each of the TARP systems (Mainstream, Calumet, Lower Des Plaines, and O'Hare) consists of three component systems: reservoirs, conveyance tunnels, and sewage treatment plants. For the TARP project as a whole, the planned component systems include three storage reservoirs, approximately 120 miles of conveyance tunnels, and four sewage treatment plants. McCook, the main storage reservoir, will have a capacity of about 64,000 ac-ft and will be located at McCook quarry, which is adjacent to the Sanitary and Ship Canal and the Des Plaines River. One of the other two reservoirs, will be located near the northwest boundary of O'Hare International Airport and the other approximately six miles south of the existing Calumet Sewage Treatment Works. The O'Hare reservoir will be a small surface storage reservoir with a capacity of 2,700 ac-ft and Thornton Quarry, the Calumet reservoir will have a much larger storage volume of about 39,000 ac-ft.

The conveyance tunnels, located 150 to 290 feet below ground level, will be constructed under existing waterways or public rights-of-way, and within, for most of the route, the silurian limestone (dolomite) geologic formation. Mining machines or "moles" will be used to excavate most of the tunnels, which presently range from 10 to 30 feet in diameter.[1] The tunnels will be concrete-lined as required in certain areas. The lining thickness will range from 7 to 23 inches, based on one-half inch per foot of tunnel diameter and two additional inches. For the entire 120-mile length, the total wastewater capacity of the conveyance tunnels is approximately 9,200 ac-ft.

The combined-sewer wastewater collected in the storage reservoirs will be conveyed by gravity flow through the conveyance tunnels to the treatment plant. Three of the four treatment plants are currently activated sludge plants with a combined planned-capacity of approximately 2,150 MGD. The three plants include: North-Side, West-Southwest, and Calumet. The remaining plant is a proposed treatment facility with a planned-capacity of about 70 MGD to be located within the O'Hare-Des Plaines area. All four treatment plants will be designed to process wastewater at a continuous rate of one and one-half times the dry weather wastewater flow rates projected for 1985. This continuous rate is equivalent to 3,700 cfs or approximately 2,400 MGD. A water reclamation plant, the John F. Egan plant, is presently under construction and will have a capacity of 30 MGD.

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[1] The diameter expressed is an equivalent diameter, since tunnels will be somewhat oval-shaped and not a true circle.

A water reclamation plant, the John F. Egan plant is presently under construction and will have a capacity of 30 MGD.

5.1.2 TARP Subsystems

The subsystems common to all TARP systems include collecting structures, drop shafts, and pumping stations. In addition, the groundwater protection program and the tunnel grouting program are considered common subsystems. This section presents a brief description of these subsystems.

(1) Collecting Structures

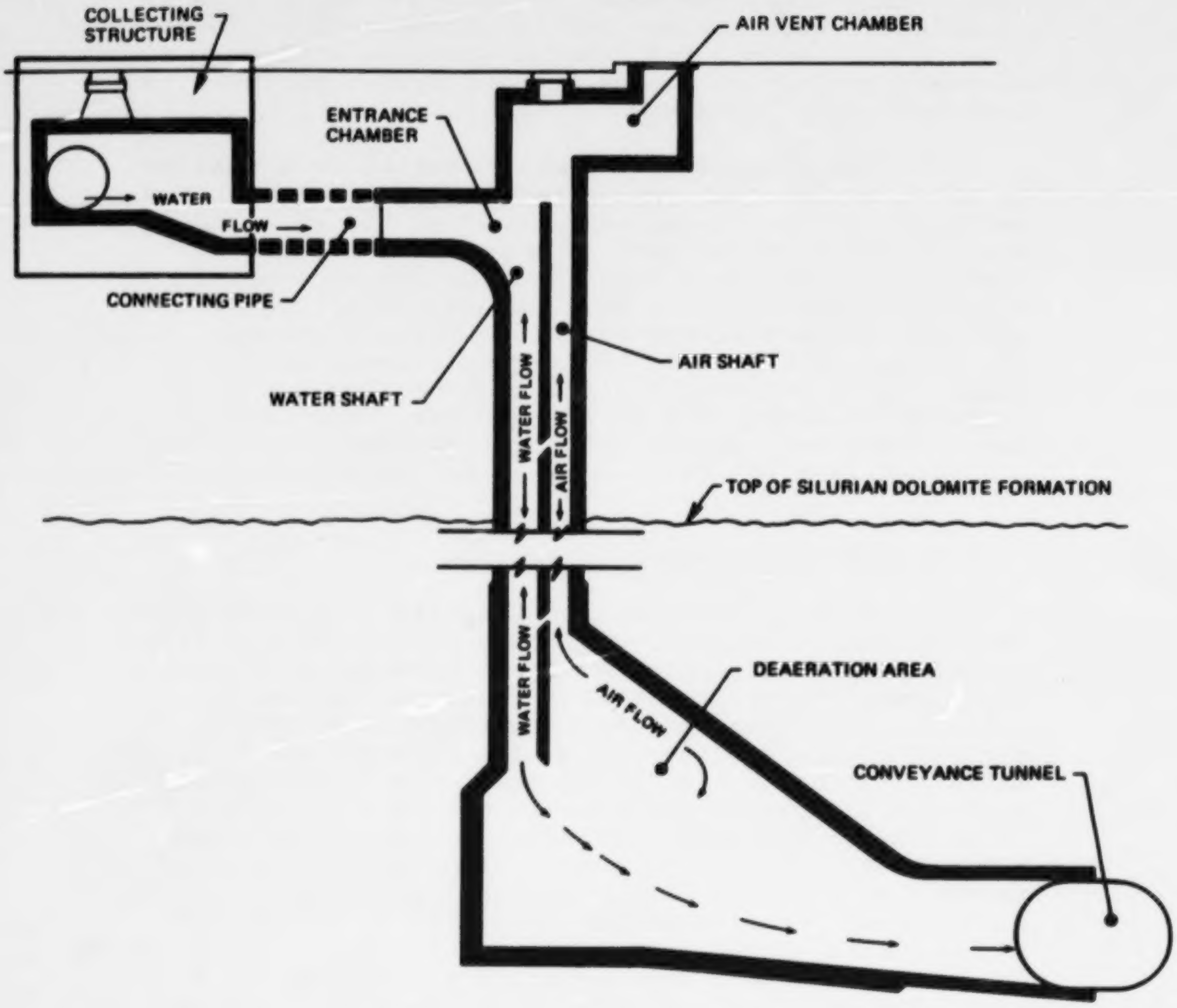
New intercepting structures to collect existing combined-sewer overflows are shown in Figure V-2. The collecting structure consists of a diversion unit at the overflow point and a connecting pipe to the entrance chamber of the drop shaft. Most of the new structures will be located near curbs or low points of major public thoroughfares. For collecting flows from existing interceptors, the structure consists of an overflow weir in addition to the diversion unit. The weir will allow the flow from existing interceptors to pass through the connecting pipe along with the flow from the new structure.

(2) Drop Shafts

The drop shaft accepts the flow from the collecting structures and diverts this flow to the conveyance tunnel. Figure V-2 illustrates the type EM15 drop shaft which is one of the two drop shaft designs proposed for the TARP systems. The EM15 drop shaft will have a dividing wall with slots to aerate the incoming water. Since the fall distance of the incoming water is expected to range from 200 to 280 feet, aeration of the water will reduce the impact at the bottom of the drop shaft. The dividing wall of the shaft allow air to enter or to escape on one side and water to flow in or to be pumped out on the other, larger side.

The other drop shaft design is the DW4 type which features a separate air vent shaft instead of a dividing wall. Although the concept and design features of both drop shaft types are similar, the purpose and the physical dimensions are different. The EM15 drop shaft has a finished inside diameter of 4 to 9 feet and will be used for low flow rate areas. The DW4 has a 10 to 17 foot diameter and will be used for high flows.

FIGURE V-2
EM15 Drop Shaft
and Collecting Structure


COLLECTING STRUCTURE
AIR VENT CHAMBER
ENTRANCE CHAMBER
WATER
FLOW
CONNECTING PIPE
AIR SHAFT
WATER SHAFT
WATER FLOW
AIR FLOW
TOP OF SILURIAN DOLOMITE FORMATION
DEAERATION AREA
WATER FLOW
AIR FLOW
CONVEYANCE TUNNEL

(3) Pumping Stations

Pumping stations will be constructed underground at the end of all conveyance tunnels and adjacent to all storage reservoirs. These stations permit dewatering of the tunnels and reservoirs at a rate which will allow a full tunnel or reservoir to be emptied within two to three days. If dewatering can be accomplished within this time, the need for aeration facilities is eliminated, thus saving some treatment costs. In addition to dewatering, the pumping stations will be used to transport bottom sludge dredged from reservoirs to treatment facilities.

The capacity of each pump installed in a station is rated at 265 cfs, or 171 MGD. The number of pumps necessary for each station depends on the expected maximum water inflow rate of a particular tunnel or reservoir. The pumps are driven by variable-speed electric motors powered by Commonwealth Edison substations located in the vicinity of the stations. The lift-height (static head) requirements of the pumps, which provide an indication of pump depth, is expected to range from 60 to 300 feet. The actual requirement will depend on operating conditions encountered when the TARP systems are implemented.

(4) Groundwater Protection Program

Groundwater infiltration into the component systems (tunnels and reservoirs) may occur at rates significant enough to deplete aquifers used as water supply resources. To protect these resources, an aquifer protection program has been incorporated in TARP. The program consists of grouting, installation of recharge wells, and tunnel lining as required to limit groundwater inflow rates to a maximum of 1.5 MGD, or 2.3 cfs. This maximum rate limit is based on the established 500 gallons per inch of tunnel diameter, per mile of tunnel, per average day. In tunnel segments requiring a number of recharge wells, they will be constructed approximately 1,000 feet apart. The areas where recharge wells may be needed are described in Section 8.1.2, part (2). The wells will be used as a means of injecting potable water or water of equivalent quality into the aquifer to increase the piezometric or hydraulic pressure level. Thus, the aquifer will be replenished to its original level. In addition, wastewater exfiltration or outflow from the conveyance tunnels will be prevented.

To monitor the extent of groundwater infiltration and wastewater exfiltration, observation wells will be installed, and the sampling program to be followed is described in Section 10.1.4, part (2).

(5) Grouting Program

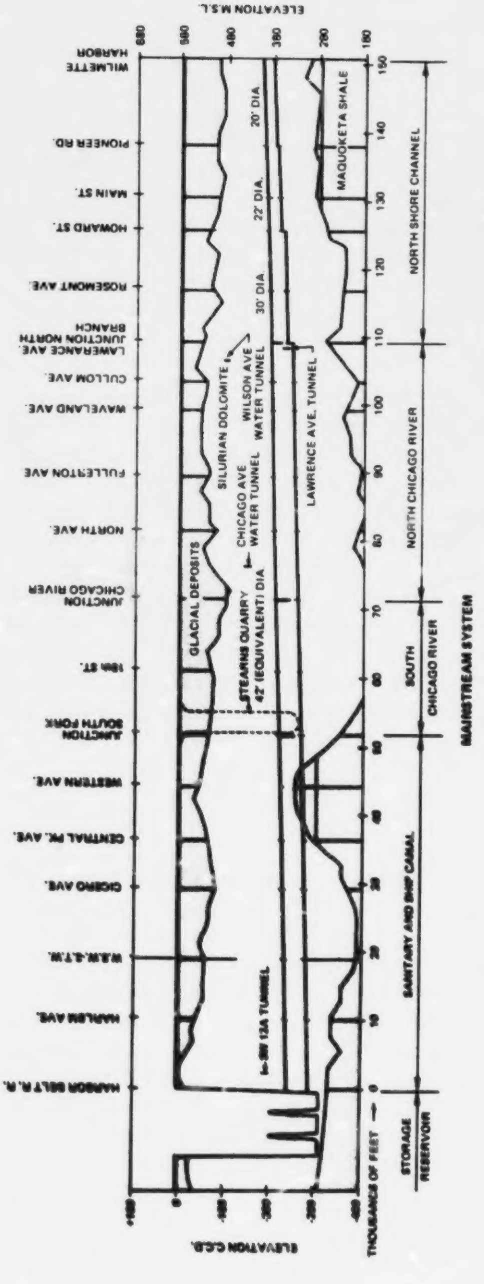
The objective of the grouting program is to achieve maximum penetration and a uniform grout spread for the purpose of effectively reducing groundwater infiltration and wastewater exfiltration. The pattern and orientation of grout holes in the TARP conveyance tunnels will depend on the observed amount of groundwater infiltration. In areas with relatively high inflow rates, an impermeable zone at least equal to the tunnel diameter will be provided around the perimeter of the tunnel.

Cement grout, which is a mixture of cement and water, will be injected under pressure into a drilled hole that intersects a source of seepage such as an open joint, fault, or bedding plane. The grout mix will be composed of cement, sand, and water in varying proportions. Liquifiers will also be used as required to counteract normal grout shrinkage, to retard grout setting time when pumping at low rates, and to increase flowability of thick grout mixes used at high inflow areas. The water-cement ratio of the grout to be used will vary from location to location within the tunnel and may even vary at a given location. The range in water-cement ratio by volume is about 0.6:1 to 10:1.

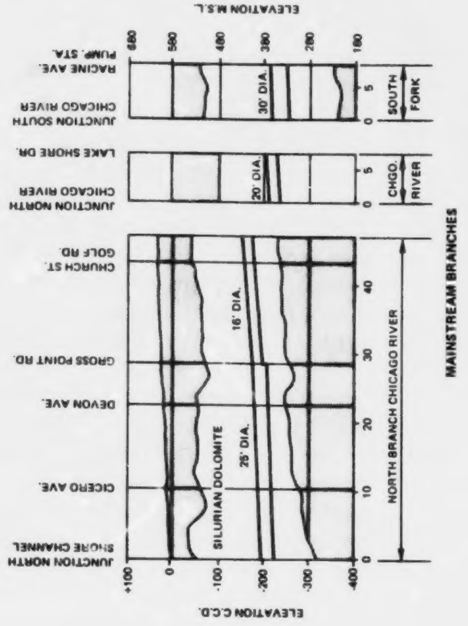
5.2 THE MAINSTREAM SYSTEM

The components of the TARP Mainstream system include: two waste treatment plants, over 57 miles of conveyance tunnel, and a proposed storage reservoir. The Mainstream system layout, Figure V-1, shows a conveyance tunnel extending from 59th Street, under the Sanitary-Ship Canal and Chicago River, to the confluence of the North Shore Channel and North Branch of the Chicago River. At this point the system branches out in two directions under these water systems, following the North Shore branch extending to Wilmette and the North Branch extending to the boundary of the MSDGC combined-sewer service area. Figure V-3 provides an overall profile view of the Mainstream system and shows major streets, river system segments, and tunnel elevations.

FIGURE V-3
Mainstream System Profile



ELEVATION M.S.L.
680
580
480
380
280
180
ELEVATION C.C.D.
+100
0
-100
-200
-300
-400
THOUSANDS OF FEET
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
WILMETTE HARBOR
PIONEER RD.
MAIN ST.
HOWARD ST.
ROSEMONT AVE.
JUNCTION NORTH BRANCH
LAWRENCE AVE.
CULLOM AVE.
WAVELAND AVE.
FULLERTON AVE
NORTH AVE.
JUNCTION CHICAGO RIVER
18th ST.
JUNCTION SOUTH FORK
WESTERN AVE.
CENTRAL PK. AVE.
CICERO AVE.
W.S.W.-S.T.W.
HARLEM AVE.
HARBOR BELT R.R.
GLACIAL DEPOSITS
SILURIAN DOLOMITE
CHICAGO AVE WATER TUNNEL
WILSON AVE WATER TUNNEL
STEARNS QUARRY
42' (EQUIVALENT) DIA
LAWRENCE AVE. TUNNEL
MAQUOKETA SHALE
20' DIA.
22' DIA.
30' DIA
SW 13A TUNNEL
STORAGE RESERVOIR
SANITARY AND SHIP CANAL
SOUTH CHICAGO RIVER
NORTH CHICAGO RIVER
NORTH SHORE CHANNEL
MAINSTREAM SYSTEM



ELEVATION M.S.L.
680
580
480
380
280
180
ELEVATION C.C.D.
+100
0
-100
-200
-300
-400
RACINE AVE. PUMP. STA.
JUNCTION SOUTH CHICAGO RIVER
LAKE SHORE DR.
JUNCTION NORTH CHICAGO RIVER
GOLF RD.
CHURCH ST.
GROSS POINT RD.
DEVON AVE.
CICERO AVE.
JUNCTION NORTH SHORE CHANNEL
30' DIA.
20' DIA.
16' DIA.
26' DIA.
SILURIAN DOLOMITE
0
5
0
5
0
10
20
30
40
SOUTH FORK
CHGO. RIVER
NORTH BRANCH CHICAGO RIVER
MAINSTREAM BRANCHES

KEY:

C.C.D. - CHICAGO CITY DATUM
M.S.L. - MEAN SEA LEVEL
"0" C.C.D. ELEVATION EQUALS 579.48' MSL

The over 57 miles of conveyance tunnel will be constructed in two phases. Phase I involves construction of about 40 miles of tunnel which will be the main wastewater conveyance system. The remaining 17 miles will be constructed in Phase II, almost parallel to the lower portion of the main line route, to be used primarily as a relief system. The Mainstream conveyance tunnel will have 134 drop shafts and a storage volume of approximately 3,180 ac-ft.

The two treatment plants associated with the Mainstream System are the North-Side and the West-Southwest Sewage Treatment Works. The North-Side plant will have a capacity of 436 MGD and will process wastewater from the northern half of the Mainstream system. The West-Southwest plant will have a larger capacity of 1,358 MGD and will process wastewaters from both the southern half of the Mainstream system and the Lower Des Plaines system.

The combined-sewer overflow conveyed by the system's tunnels will be stored in the proposed Mainstream system reservoir which will also store overflow wastewater conveyed by the Lower Des Plaines system. The storage capacity planned for this reservoir is 64,000 ac-ft, the projected wastewater inflow from both of these systems can be stored for periods up to nine months. Aeration systems will be installed in the main storage reservoir to control odor and septicity if storage must exceed the three day limit.

The portion of the Mainstream system addressed by this environmental impact statement is described in detail in the following sections; Component System and Component Subsystems. The component system is the Mainstream conveyance tunnel only, not including reservoirs and waste treatment plants. In addition, the tunnel route to be addressed is the 59th Street to Addison Street segment, excluding the North Branch of the Chicago River, Addison Street to Wilmette, and the relief tunnel segments of the Mainstream system. The subsystems described are associated with the conveyance tunnel and include drop shafts, collecting structures, and pumping stations.

5.2.1 Component System

The total area served by the Mainstream conveyance tunnel system from 59th Street to Addison Street is 152.5 square miles, within the MSDGC "Central Facility Area." The 59th-to-Addison service area is presently served by local combined-sewer systems, and 124.2 of the total square mile area is within the Chicago city limits. The remaining 28.3 square miles include the suburban communities of Berwyn, Cicero, Lyons, McCook, Stickney Forest, and Summit.

The overall length of the 59th-to-Addison tunnel is 21.2 miles and the total number of subsystems of this segment includes 82 drop shafts, 5 construction shafts, 2 access shafts, and 1 pumping station. The tunnel segment will be excavated using full-faced, diesel driven, mechanical boring machines, or moles, and the inside diameters will range from 15 to 33 feet. Most of the tunnel will be lined with 12 inches of concrete and will be excavated at an average rate of 25 feet per day (net), based on a 24-hour work day and a six-day work week. In the unlined portions, rock bolting and grouting will be done to assure rock bed stability and to minimize infiltration of groundwater or exfiltration of wastewater.

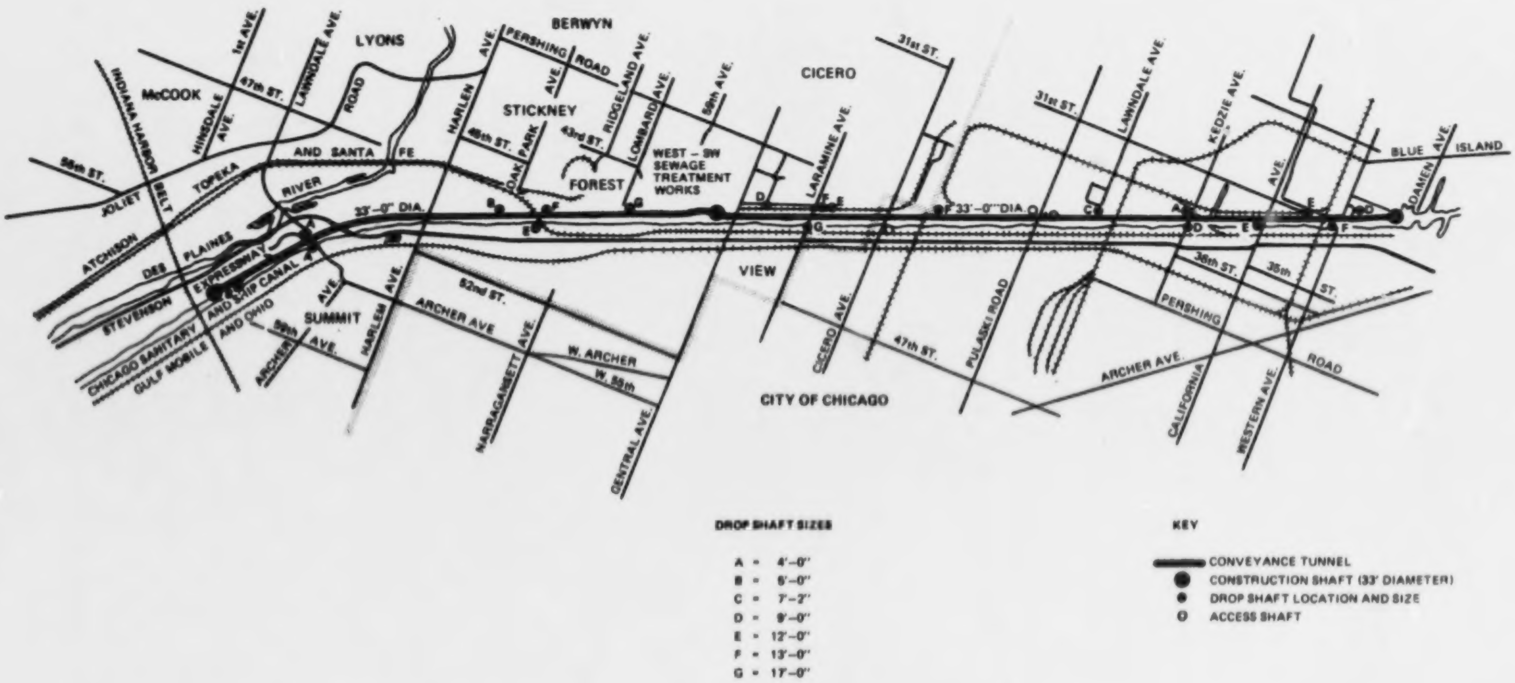
Until the capacity of the West-Southwest sewage treatment works is expanded to 1,358 MGD, the dewatering rate of the Mainstream conveyance tunnels is restricted to the treatment works' existing capacity of 866 MGD, or 1340 cfs. The 866-MGD dewatering rate results in a tunnel flushing velocity of 6.7 feet per second or greater for a period of about four and one-half hours. Thus, the dewatering cycle provides self-cleaning for the tunnel system and minimizes accumulation of bottom sludge, debris, and other benthal deposits.

Several features are characteristic of specific tunnel sections within the 59th-to-Addison segment. The 59th-to-Addison segment has been divided into two sections; 59th Street to Damen Avenue, and Damen Avenue to Addison Street.

(1) 59th Street to Damen Avenue Tunnel

This tunnel has an overall length of 45,100 feet (8.5 miles). Figure V-4 is a map showing the proposed tunnel route in relation to the area's major thoroughfares, rail lines, and communities. The tunnel will have a finished diameter of 33 feet and a slope of 0.2 feet per 1,000 feet. The upstream and downstream tunnel-bottom elevations are -255.38 CCD (Chicago City Datum) and -264.00 CCD, respectively. In terms of Mean Sea Level (MSL), the corresponding elevations are 324 feet and 315 feet.

FIGURE V-4
Mainstream System -
59th Street to Damen Avenue
Conveyance Tunnel



McCOOK
LYONS
BERWYN
STICKNEY
CICERO
FOREST
VIEW
SUMMIT
CITY OF CHICAGO
WEST - SW SEWAGE TREATMENT WORKS
INDIANA HARBOR BELT
HINSDALE AVE.
1st AVE.
47th ST.
LAWNDALE AVE.
ROAD
58th ST.
JOLIET
ATCHISON
TOPEKA
AND SANTA FE
RIVER
DES PLAINES
EXPRESSWAY
STEVENSON
CHICAGO SANITARY AND SHIP CANAL
GULF MOBILE AND OHIO
ARCHER AVE.
59th AVE.
33'-0" DIA.
HARLEN AVE.
HARLEM AVE.
PERSHING ROAD
46th ST.
OAK PARK AVE.
43rd ST.
RIDGELAND AVE.
LOMBARD AVE.
56th AVE.
52nd ST.
ARCHER AVE
NARRAGANSETT AVE.
W. ARCHER
W. 55th
CENTRAL AVE.
LARAMINE AVE.
31st ST.
CICERO AVE.
47th ST.
PULASKI ROAD
33'-0" DIA.
31st ST.
LAWNDALE AVE.
KEDZIE AVE.
AVE.
BLUE ISLAND
DAMEN AVE.
36th ST.
35th ST.
PERSHING ROAD
ARCHER AVE.
CALIFORNIA
WESTERN AVE.
A
B
C
D
E
F
G
DROP SHAFT SIZES
A = 4'-0"
B = 5'-0"
C = 7'-2"
D = 9'-0"
E = 12'-0"
F = 13'-0"
G = 17'-0"
KEY
CONVEYANCE TUNNEL
CONSTRUCTION SHAFT (33' DIAMETER)
DROP SHAFT LOCATION AND SIZE
ACCESS SHAFT

Based on the geologic and hydraulic characteristics of the area, the conveyance tunnel will be aligned primarily within the dolomite (Kankakee and Edgewood formations) and shale (Brainard formation) deposits with an overall rock cover of 180 feet minimum. The crown area of one section of tunnel will be in the Joliet dolomite formation. This section is approximately 15,000 feet long and centered near Central Avenue.

Two 33-foot diameter construction shafts will be located on the 59th-to-Damen section of the Mainstream tunnel route. One shaft will be at the end of the route near 59th Street and the other will be within the West-Southwest treatment works boundary near Central Avenue. Construction equipment, machines, and material will be transported into the tunnel through these shafts. During the tunnel construction phase, rock and spoil material will be removed through one of these shafts.

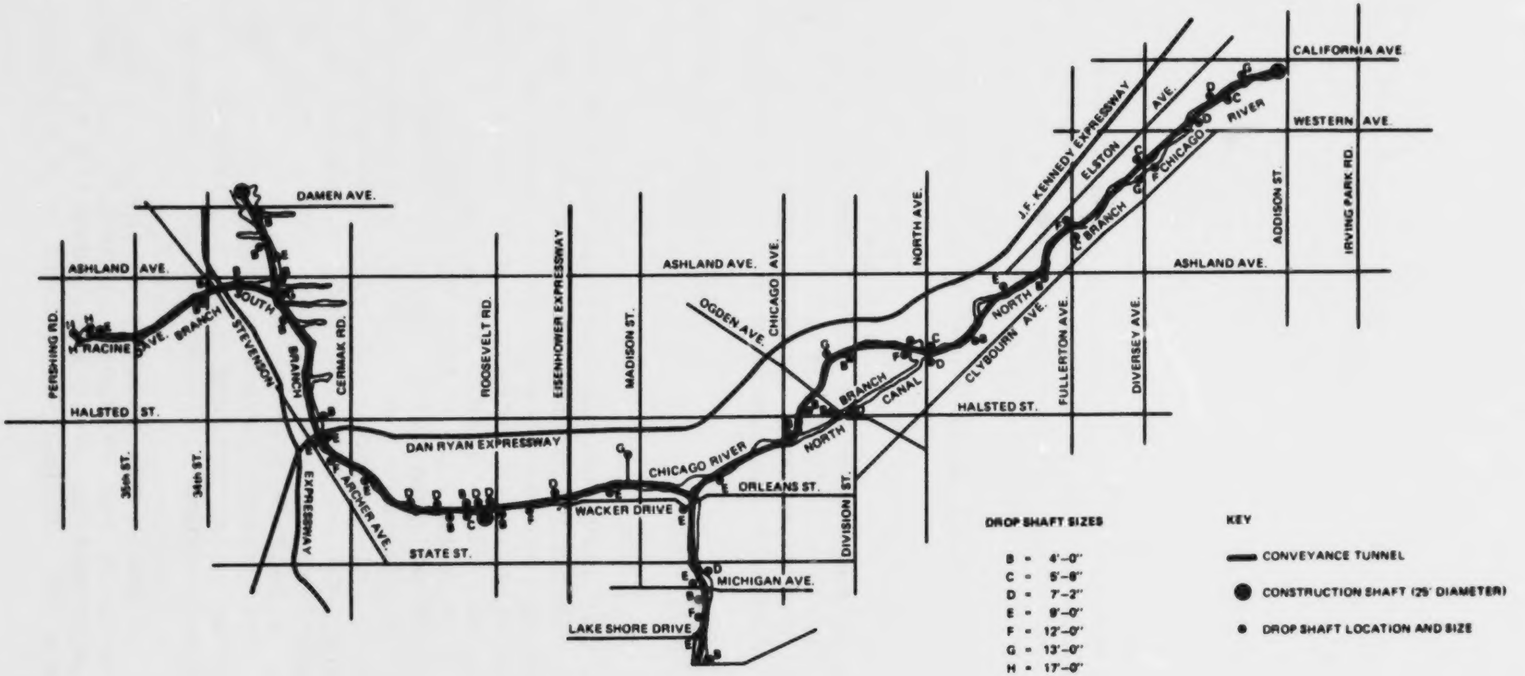
(2) Damen Avenue to Addison Street Tunnel

The Damen-to-Addison tunnel section will have a finished diameter of 30 feet for a length of 60,350 feet (11.4 miles) and 13 feet for a length of 6,500 feet (1.2 miles). The route of this tunnel section and its relationship to major thoroughfares, rail lines, and waterways of the area are shown in Figure V-5. Two tunnel branches; Racine Avenue and Chicago River-Wolf Point, are a part of the Damen-to-Addison tunnel. One branch extends eastward toward Lake Michigan and the other extends southward under the South Fork of the Chicago River.

The slope of the conveyance tunnels range from 0.2 to 0.4 feet per 1,000 feet of tunnel. Between Damen Avenue and Chicago Avenue, the tunnel slope will be 0.2 feet per 1,000 feet and between Chicago Avenue and Addison Street, 0.4 feet per 1,000 feet. The elevations reflecting this slope are -254.99 CCD (324 MSL) and -239.34 CCD (340 MSL), respectively.

The tunnels will be aligned predominantly within the Joliet and Racine dolomite formations. However, a short 4,000-foot section will be in the Kankakee dolomite formation between Damen and Ashland Avenues, 1,000 feet of which will be in the Edgewood formation,

FIGURE V-5
Mainstream System -
Damen Avenue to Addison Street
Conveyance Tunnel


DAMEN AVE.
ASHLAND AVE.
PERSHING RD.
35th ST.
34th ST.
HALSTED ST.
RACINE AVE.
SOUTH BRANCH
STEVENSON EXPRESSWAY
ARCHER AVE.
CERMAK RD.
ROOSEVELT RD.
EISENHOWER EXPRESSWAY
MADISON ST.
DAN RYAN EXPRESSWAY
STATE ST.
WACKER DRIVE
CHICAGO RIVER
MICHIGAN AVE.
LAKE SHORE DRIVE
ORLEANS ST.
OGDEN AVE.
CHICAGO AVE.
DIVISION ST.
NORTH BRANCH CANAL
NORTH AVE.
CLYBOURN AVE.
NORTH BRANCH CHICAGO RIVER
J.F. KENNEDY EXPRESSWAY
ELSTON AVE.
FULLERTON AVE.
DIVERSEY AVE.
ADDISON ST.
IRVING PARK RD.
WESTERN AVE.
CALIFORNIA AVE.
DROP SHAFT SIZES
B - 4'-0"
C - 5'-6"
D - 7'-2"
E - 9'-0"
F - 12'-0"
G - 13'-0"
H - 17'-0"
KEY
CONVEYANCE TUNNEL
CONSTRUCTION SHAFT (25' DIAMETER)
DROP SHAFT LOCATION AND SIZE

which consists of cherty (flintlike) and shaley dolomite. This alignment was based on the area's providing geologic and hydraulic features and provides a rock cover of 95 to 195 feet above the crown of the tunnels.

Excavation moles and other construction machines as well as equipment and material will be transported through three 25-foot diameter construction shafts. The construction shafts will be located at both ends of the Damen Avenue and Addison Street tunnel segment, and near Roosevelt Road adjacent to the Chicago River. Construction equipment and machines for excavating the Racine tunnel branch will be introduced in the 59th-to-Damen tunnel segment, which will be completed by the time construction starts on this branch. For the Chicago River-Wolf Point branch, machines and equipment will enter from a heading or starter-tunnel located in the main tunnel at Wolf Point. As stated for the 59th-to-Damen tunnel segment, rock and spoil material will be removed through these construction shafts.

5.2.2 Component Subsystems

The subsystems of the Mainstream Conveyance Tunnel system include drop shafts, pumping stations, and surface collecting structures. In this section, the sizes, locations, and number of these subsystems are described by the previously identified tunnel segments.

(1) 59th Street to Damen Avenue Tunnel

Twenty-two drop shafts will be constructed to intercept and transfer wastewater overflows to the tunnel system. The finished diameters of these drop shafts will vary as shown on the following page.

No. of Shafts	Finished Diameter	Type
2	17'	DW4
4	13'	DW4
4	12'	DW4
4	9'	EM15
1	7'2"	EM15
2	5'8"	EM15
4	4'	EM15
1	2'	EM15

Total: 22

Figure V-3 shows the location of the 22 drop shafts along the conveyance tunnel route and Table V-1 summarizes the number, locations and sizes of the shafts.

The main pumping station for this segment of the tunnel system will be constructed underground adjacent to the 59th Street construction shaft, which is at the downstream end of the conveyance tunnel route. Four pumps will be installed approximately 40 feet below the tunnel bottom elevation and each pump will have a rated capacity of 265 cfs or about 170 MGD. For removing any infiltrated groundwater from the tunnel, a 5,000-GPM capacity pump will be installed at the station.

The 59th-to-Damen tunnel will consist of 45 collecting structure connections intercepting the combined-sewer overflows. Thirty-three drop shaft connections will intercept the overflow points directly, 2 drop shaft connections lead to new adjacent interceptors, and 10 overflow connections lead to existing interceptors. The structures for the 10 existing interceptor connections will consist of conduits of sufficient size to allow the full capacity of the existing sewer to flow to the interceptor without any overflow surface water systems. Therefore, the existing interceptors will be relieved at 10 points.

Table V-1
59th Street to Damen Avenue Tunnel - Summary of Drop Shaft Number, Location, and Size

Shaft No.	Drop Shaft Location	Finished Diameter
1(1)	75th Street (Ext.) Hodgkins (West)	5'8" (C*)
2(1)	75th Street (Ext.) Justice (East)	4'0" (C)
3(1)	67th Street (Ext.) Bedford Park (East)	9'0" (C)
4	Lawndale Avenue Summit (West)	4'0" (C,S**)
5	Lawndale Avenue Summit (East)	4'0" (S)
6	Southwest 13A Intercepting Sewer	2'0"
7	Grove Avenue (North)	5'8"
8	South Natchez Outfall (Ext.) (South)	12'0"
9	Hiawatha Avenue (Ext.) (North)	13'0" (C)
10	Lombard Avenue (Ext.) (North)	17'0"
11	West Side Treatment Plant (North)	9'0"
12	Leamington Avenue Outfall	17'0"
13	South Laramie Ave. (Ext.) (North) SW/1	13'0"
14	South Laramie Ave. (Ext.) (North) W/1	12'0"
15	South Kilbourne Ave. (Ext.) (North)	13'0"

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1 Not included as part of the proposed action.

* C = Combined shaft.

** S = Sloped shaft.

Table V-1
Continued

Shaft No.	Drop Shaft Location	Finished Diameter
16	South Lawndale Ave. (Ext.) (North)	7'2"
17	South Kedzie Ave. (South)	9'0"
18	South Kedzie Ave. (North)	4'0" (S)
19	South California Ave. (South)	12'0"
20	South Rockwell Street (Ext.) (North)	12'0"
21	South Western Avenue (South)	13'0"
22	South Oakley Avenue (Ext.) (North)	9'0"

(2) Damen Avenue to Addison Street Tunnel

The Damen-to-Addison segment will have 62 drop shafts constructed to intercept the overflows and convey them to the tunnels. The finished diameters of these drop shafts vary from 4 feet to 17 feet. The numbers and sizes are as follows:

No. of Shafts	Finished Diameter	Type
3	17'	DW4
5	13'	DW4
6	12'	DW4
11	9'	EM15
10	7'2"	EM15
6	5'8"	EM15
21	4'	EM15

Total: 62

The location of the shafts along this segment of the Mainstream route is shown in Figure V-4. A summary of drop shafts is presented in Table V-2.

This portion of the tunnel system will not have a separate pumping station. All wastewater overflows will be conveyed by gravity to the main or 59th Street pumping station.

The tunnel segment design includes a total of 125 collecting structure connections intercepting the combined-sewer overflows. Fifty-three of these drop shaft connections will intercept overflows directly, 9 will connect to existing interceptors nearby, and 63 will connect directly to existing interceptors. All existing overflow connections will be maintained to enable relief of the combined-sewer system when the tunnels become filled.

To eliminate direct overflow discharge to waterways, 70 existing combined sewers will be connected directly to the interceptors, providing conduits of sufficient size to allow maximum flow to the interceptors in the event existing sewer lines are filled to capacity. Therefore, 63 interceptor relief points are provided for the existing interceptors.

Table V-2
Damen Avenue to Addison Street Tunnel - Summary of Drop Shaft Number, Location, and Size

Shaft No.	Drop Shaft Location	Finished Diameter
23	South Damen Avenue (North)	4'0" (S)
24	South Wood Street (Ext.) (South)	4'0" (S)
25	South Paulina St. (Ext.) (North)	9'0"
26	Racine Avenue Pumping Station	9'0"
27	Racine Avenue Pumping Station	17'0"
28	Racine Avenue Pumping Station	17'0"
29	Racine Avenue	17'0"
30	West 35th Street (West)	7'2"
31	31st Street	4'0" (S)
32	Archer Avenue	4'0" (S)
33	Ashland Avenue (South)	4'0"
34	Ashland Avenue (North)	4'0"
35	Laflin Street	13'0"
36	Loomis Street	4'0" (S)
37	Halsted Street	4'0"
38	Dan Ryan Exp.	9'0"
39	24th Street Pumping Station	9'0"
40	Normal Avenue	12'0"
41	Canal Street & Grove Street	9'0"
42	18th Street	7'2"
43	16th Street	7'2"

Table V-2
Continued

Shaft No.	Drop Shaft Location	Finished Diameter
44	15th Street	4'0" (S)
45	14th Street	5'8"
46	14th Street (West)	4'0" (S)
47	Maxwell Street	7'2"
48	Roosevelt Road (East)	4'0"
49	Roosevelt Road (West)	7'2"
50	Taylor Street	12'0"
51	Harrison Street	7'2"
52	Quincy Street	9'0"
53	Jefferson Street & West Monroe Street	13'0"
54	Wacker Drive & Franklin Street	9'0"
55	Michigan Avenue & Wacker Drive	9'0"
56	Stetson Avenue	4'0" (S)
57	Wacker Drive & Columbus Drive	5'8"
58	Lake Shore Drive (South)	9'0"
59	Lake Shore Drive (North)	4'0"
60	St. Clair Street	12'0"
61	Kinzie Street	9'0"
62	West Chicago Ave. (West)	4'0"
63	North Halsted St. (North)	4'0"
64	West Cortez Street & North Elston Ave. (West)	13'0"

Table V-2
Continued

Shaft No.	Drop Shaft Location	Finished Diameter
65	West Division St. (East)	4'0" (S)
66	West Blackhawk St. (West)	12'0"
67 & 68	North Halsted St. & North Branch Canal (North)	7'2"
69	West Blackhawk St. (East)	4'0"
70	West North Avenue (East)	5'8"
71	West North Avenue (West)	7'2"
72	North Clifton Ave. (East)	4'0" (S)
73	West McLean Avenue (West)	9'0"
74	North Ashland Ave. (North)	4'0" (S)
75	West Fullerton Ave. (East)	12'0"
76	West Fullerton Ave. (West)	5'8"
77	North Damen Avenue (South)	4'0" (S)
78	West Diversey Pkwy. (East)	5'8"
79	West Diversey Ave. & West Logan Blvd. (West)	13'0"
80	North Leavitt St. (North)	12'0"
81	North Western Ave. (North)	7'2"

Table V-2
Continued

Shaft No.	Drop Shaft Location	Finished Diameter
82	West Belmont Avenue (West)	7'2"
83	West Melrose Street & North Rockwell St. (East)	5'8"
84	West Roscoe Street (West)	13'0"
85	West Addison Street (East)	12'0"

5.3 OPERATION OF THE TUNNEL SYSTEM, 59TH STREET TO ADDISON STREET

This section describes the important operation, maintenance, and management steps necessary to maintain for proper functioning of the tunnel system. This section also provides estimates of operation and maintenance costs. Each of the actions is treated separately below.

5.3.1 Operation Steps

The operation of the tunnel system has one basic step during wet weather conditions. This step is the dewatering of the tunnel at rates which do not overburden the treatment capacity of the West-Southwest Sewage Treatment Works (WSWSTW). In other words, the flow rate of water pumped from the tunnels plus the flow rate of water from other sewers which connect to the WSWSTW must not exceed the allowable peak flow through the WSWSTW. The operator of the pumping station uses two or more of the four variable speed pumps simultaneously to set the dewatering rate so that normally, total flow through the WSWSTW will be less than or equal to design flow. When required, such as during periods of extremely wet weather, and during subsequent full tunnel flow, the dewatering rate can be increased so that total flow through the treatment system is at allowable peak flow. Thus, in order to properly control the dewatering pump rate, the operator must constantly monitor the allowable flow rate through the WSWSTW. This allowable rate will depend on three variables: the extent of "downtime" for scheduled maintenance, the frequency of malfunctions, and the extent of capacity to be added to the plant.

Another controlling factor for setting pump rates is the maximum tunnel inflow rate. Since the tunnels can become pressurized in the beginning of a large storm event, the dewatering rate must be slightly greater than the maximum inflow rate to prevent pressurization.

During the heaviest storms, when some overflow to waterways is unavoidable, gates at selected drop shafts at downstream locations will be closed by the operator to force the occurrence of overflows at locations along the Sanitary and Ship Canal. Such action will maintain sufficient capacity in the upstream portions of the tunnel to eliminate overflows close to the Lake Michigan shoreline.

High dewatering rates are necessary to achieve velocies of tunnel water which will scour sediment from the tunnel floor. When dewatering time is increased, removal of sediment is increased as well. To remove more sediment, the operator would increase dewatering time from about four and one-half hours to eight hours by directing about 240 cfs of canal water to a drop shaft upstream of the pumping station. The operator would pump this canal water to the WSWSTW.

During dry weather periods, only infiltrating water from aquifers will flow into the tunnel. To rid the tunnel of this water, the pumping station operator will use a separate pump with a capacity of about 5,000 gpm to lift the water to the treatment system. This dewatering of infiltrating groundwater could probably be made automatic if necessary. To perform the dewatering manually, the operator must shut the pump off when there is not enough water to warrant its use as well as shut it off in wet weather when the main dewatering pumps are in use.

A routinely required step that is critical to the system is checking and testing the power sources to the pumps. Lack of power during wet weather could result in polluting overflows at interceptor connections, drop shafts, and outfalls.

5.3.2 Maintenance Steps

Required maintenance of the system comprises four areas:

(1) Equipment Maintenance

Pumps, pump controls, and power supply equipment routinely must be checked and maintained.

(2) Repair to Tunnel Lining

Those areas of the tunnels which are lined, bolted, grouted, or otherwise stabilized, will require periodic checking for leaks and structural faults, and periodic repairing as necessary.

(3) Maintenance of Surface Structures

Surface structures will be built at construction shafts, drop shafts, and the pumping station. All will require routine maintenance to assure adequate appearance, structural soundness, and safety for workers and visitors. Access roads must be kept in repair as well.

(4) Tunnel Sludge Cleaning

The tunnels will be designed so that dewatering will scour the tunnel floor. However, some sludge may accumulate over periods of several years and may eventually require removal. If removal becomes necessary, the deposits will be gathered with a dragline, lifted to the surface through construction shafts, and transported by truck to appropriate disposal areas. The material is not expected to be odiferous or difficult to dispose of in an environmentally sound manner, because it will probably be composed mostly of sand, and partly of silt and benthal deposits.

5.3.3 Operation and Maintenance Costs

The best estimate of operation and maintenance costs at the time of publication of this report is an annual equivalent cost of $2.8 million. This estimate is based on the one given in the environmental impact statement prepared for the MSDGC in November 1973.[1] The total TARP equivalent annual cost was given as $13.6 million, which included total equivalent annual operating and maintenance costs, replacement of equipment costs, and water costs for aquifer protection. The estimate of $2.8 million for the 59th Street to Addison Street segment of the tunnel system was derived as the product of the ratio of tunnel volume for this segment to total TARP tunnel volume times the total cost of $13.6 million.[2] The ratio of tunnel volumes

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[1] "Preliminary Draft Environmental Impact Statement: A Plan for Control of Flood and Pollution Problems Due to Combined Sewer Discharges in the General Service Area of the Metropolitan Sanitary District of Greater Chicago," MSDGC, November 1973.

[2] $$\frac{\text{Tunnel volume (59th to Addison)}}{\text{Tunnel volume (TARP)}} \times \text{TARP O\&M Costs} = \text{59th to Addison O\&M Costs}$$

or $$\frac{1{,}891 \text{ ac-ft}}{9{,}200 \text{ ac-ft}} \times \$13.6 \text{ million} = \$2.8 \text{ million.}$$

was used because pumping station operation and maintenance costs are proportional to dewatering or tunnel volumes, and these pumping costs far outweigh any other operation and maintenance costs. The derived estimate is somewhat conservative, because the total estimate includes the water costs for aquifer protection by recharge wells. Recharge wells have been found to be no longer required, based on a recent study conducted by MSDGC.

5.3.4 Management Steps

The reliability of the tunnel system will depend heavily on the development of suitable management plans and on their routine effective execution. Important requirements of such management plans are discussed below.

(1) Pump Operation

A standard procedure will be required for controlling starting time, pumping rate, and duration of pumping. This procedure will allow for maximum possible dewatering rates to be kept within the constraints of maximum tunnel inflow and of treatment flow capacity at the WSWSTW. The first constraint is use of accurate, timely information on the maximum inflow rate and water depth in the tunnel. The second constraint is consideration in the plan of allowable flows at the WSWSTW. Since treatment capacity is likely to be increased at the WSWSTW, increases should be reflected in the pump operation plan.

(2) Canal Water Flushing

The proposed use of canal water to flush the tunnels would necessitate treatment of the water at the WSWSTW. Since treatment capacity at WSWSTW can be regarded as a scarce resource, canal water flushing should be monitored and evaluated carefully. For example, sediment build-up on the tunnel floors could be measured periodically in the cases where no canal water is used for flushing. The difference in sediment removal could then be calculated and evaluated against the costs of diverting the canal water to the tunnel and treating it at the WSWSTW.

For the proposed flushing operation, a procedure should be developed to control the timing of addition of canal water to the tunnel so that the handling capacity of the tunnel is not exceeded.

(3) Drop Shaft Gate Operation

To minimize the potential for overflowing at upstream interceptor connections and drop shafts during the heaviest storms, a procedure should be developed for the pump station operator to control the timing of closing downstream drop shaft gates. The procedure would rely on tunnel inflow rate data, tunnel water level data, and upstream drop shaft water level data. Experience under operating conditions might be necessary to perfect this procedure. Similarly, a procedure should be developed to control the duration of the gate closings to minimize the resultant overflow at downstream drop shafts.

(4) Infiltration Monitoring

Routine inspection of the tunnels and recording of groundwater dewatering rates and dry weather tunnel water level would allow for strict control of infiltration. Any significant increase in recorded infiltration could be followed up by tunnel inspection to investigate possible causes. Experience under operating conditions could be used to develop procedures for determining norms and variations from norms in dry weather tunnel flow. This might warrant investigation for leaks in tunnel lining and grouting.

(5) Training of Operators and Maintenance Crews

The management plan should make provisions for adequate training of operators. While the tunnel system itself is not complicated, the decision criteria which control the system are rather complex. It is important that all operators be both knowledgeable in the fundamentals of the decision criteria and well equipped to execute the management plan. Maintenance crews should require adequate technical training and should be well practiced in any safety procedures which the management plan might recommend.

VI. EFFECTS OF CONSTRUCTION ON THE NATURAL ENVIRONMENT

VI. EFFECTS OF CONSTRUCTION ON THE NATURAL ENVIRONMENT

This chapter describes construction impacts upon the water, land, and air resources of the Chicago area. Construction of the conveyance tunnels, in the Phase I construction period, is expected to be spaced over a ten-year period, although construction times for individual tunnel segments will be shorter than ten years.

This chapter continues the discussion begun in Chapter II, Existing Natural Environment, and is, thus, divided into the same three main sections:

- Water Resources
- Land Resources
- Atmospheric Resources.

In the water resources section, the effects of tunnel construction upon surface water and groundwater supplies are identified and evaluated. Impacts examined include those associated with dewatering of the tunnels during construction and interactions with other area water management programs.

Under land resources, construction impacts related to the geologic and seismic regimes are evaluated. The land resources section also addresses spoil disposal problems and effects upon flood-prone areas.

The section discussing impacts upon atmospheric resources includes an evaluation of the air quality impact of emissions from construction equipment, as well as impacts from noise and dust during construction activities.

6.1 WATER RESOURCES

The effect of tunnel construction on area water resources is examined in the following sections. Sections 6.1.1 and 6.1.2 evaluate construction impacts on surface water and groundwater supplies, respectively. Anticipated effects related to the disposal of water pumped from the tunnels during construction are addressed in Section 6.1.3. Foreseeable impacts on other water management programs are described in Section 6.1.4.

In general, impacts on water resources during the tunnel construction phase are expected to be minor since most of the construction activities will be carried out underground.

In addition, impacts would probably be amenable to mitigative measures, should their application prove necessary. Measures for ameliorating potential construction impacts are described in Chapter X.

6.1.1 Surface Water

Impacts on surface water quality and quantity caused by construction of the Mainstream Tunnel from 59th Street to Addison Street are discussed in this section. Effects on water quality from effluent discharged in tunnel dewatering during construction are treated separately in Section 6.1.3. The Mainstream Tunnel system may be conveniently divided into two segments for further discussion:

- 59th Street to Damen Avenue
- Damen Avenue to Addison Street.

(1) 59th Street to Damen Avenue

This tunnel segment runs parallel to the Sanitary and Ship Canal and is approximately 8.5 miles in length. Two construction shafts and 22 drop shafts will ultimately be excavated along its length (see Figure V-4, page V-10). These shafts generally will be placed in paved or otherwise impervious areas which will result in construction runoff and additional sedimentation loading of the canal and existing sewer systems during construction. Several shafts are cited in a location with high erosion potential and the construction of a berm around the site will be required to prevent soil from washing into the Sanitary and Ship Canal and adjacent sewers during rainstorms.

Stockpiles of spoil materials at the three construction shafts are expected to be small, but the potential for sedimentation of the waterways exists if a berm around the pile or other suitable controls are not provided.

Dewatering operations during construction are expected to contribute a minor amount of flow to the Sanitary and Ship Canal after appropriate treatment (see Section 6.1.3). The 59th Street to Damen Avenue segment of the Mainstream Tunnel system is expected to yield a maximum flow of about 1.7 MGD of infiltrated groundwater toward the end of the ten-year construction period, which will eventually be discharged into the Sanitary and Ship Canal. Since the average annual flow rate in the canal over the years, from 1960 to 1969, was in excess of 3,000 CFS or about 1.940 MGD,[1] the flow added during construction dewatering operations will be insignificant. The augmentation of flow to the canal is beneficial, since it will enhance navigation along the waterway.

(2) Damen Avenue to Addison Street

This tunnel segment generally follows the Chicago River and the North Branch of the Chicago River with two offshoot tunnels, the Racine Avenue Branch and the Chicago River-Wolf Point Branch (see Figure V-5, page V-12). Total length of this segment is about 12.6 miles. As shown in Figure V-5, three construction shafts and 62 drop shafts lie along its length. As on the 59th Street to Damen Avenue segment, most of these shafts are also expected to be located in paved areas and the problems of sedimentation to the waterways and to existing sewers will arise. As noted before, berms to control the runoff of soil and spoil materials will be required at the appropriate sites. No adverse impact to area waterways is expected, however, because of the developed nature of the selected shaft sites and the anticipated rapid removal of spoil material to a disposal site.

Construction dewatering operations are expected to yield a maximum flow of about 2.15 MGD over the 12.6-mile length of the tunnel segment. Since the average yearly flow along the North Branch of the Chicago River over the years 1960 to 1969 averaged well in excess of 19 MGD (lowest average yearly flow for the decade), the effect of the flow from tunnel dewatering operations is likely to be insignificant. The augmentation of flow along the waterways is, of course, beneficial to navigation.

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[1] USGS, Surface Water Supply of the United States, "Water Supply Papers Corresponding to Upper Mississippi River Basin Below Keokuk, Iowa," 1971.

6.1.2 Groundwater

During construction, infiltration of groundwater into tunnels will necessitate dewatering. Since all of the tunnel sections will be in the upper aquifer, construction should have negligible effects on the lower aquifer. Extensive inflow studies to measure piezometric or hydraulic pressure levels have been carried out by HEC in boreholes along the tunnel route, and inflow studies have been carried out in existing tunnels. Based on these data, estimates can be made of dewatering which will be required during construction, and of the effect of this dewatering on the groundwater system.

(1) Infiltration Projections

Infiltration results when the aquifer pressure level exceed pressure level in the tunnel, except during severe storms. In this case, runoff water conveyed by the tunnels will raise pressure levels to a point greater than the aquifer's level. When this occurs, exfiltration will result rather than infiltration. In view of the geohydrologic character of the upper aquifer, as discussed in Section 2.1.2, most inflow to the tunnel will occur along joints, faults, and bedding planes.

Studies of existing tunnels have indicated two significant factors concerning infiltration:

- Notable inflows in existing tunnels were generally associated with the upper and lower contact of the Romeo member of the Joliet Formation.
- Inflows through faults, bedding planes, and joints decrease with time as dissolved carbonates precipitate at leak points and seal openings.

Inflow via the contacts of the Romeo member in the proposed tunnels may not differ significantly from inflow through joints in adjacent rocks.[1] The primary solution proposed for the inflow problem will be a grouting program. Grouting should limit infiltration of groundwater to 500 gal./inch of tunnel diameter/ mile/day and will be widespread (i.e., no concentrated leakage locations will be tolerated).

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[1] Harza Engineering Company, "Geotechnical Design Report, Tunnel and Reservoir Plan, Mainstream Tunnel System," Metropolitan Sanitary District of Greater Chicago, Chicago, Illinois, 1975.

Due to the heterogeneous nature of aquifer permeability, it is difficult to predict groundwater inflow to tunnel segments. HEC[1] used water pressure test data from boreholes as input to a computer simulation to predict inflow to sections of the Mainstream Tunnel. The following is a summary explanation of their approach.

- Two different approaches were evaluated to approximate the secondary permeability of the rock mass for use with the finite element analysis. One approach expresses permeability as a function of equivalent porous rock, and the other approach expresses it as a function of only the openings between the intact rock. Using the first approach, permeability can be obtained easily from results of water pressure tests performed in drill holes. Using the second approach, difficulty is encountered in assessing the complex geometry of natural fracture systems with sufficient accuracy.

- Inflows were computed using a finite element computer program developed by Taylor and Brown.[2] This program solves problems of steady state flow through porous media. It can accommodate zones of different permeabilities in both horizontal and vertical directions. This program is easily applied, and the results are as reliable as any available method. However, the results must be used with judgement, and their sensitivity to variations in assumptions and input must be considered.

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[1] HEC, 1975.

[2] Taylor, R.L., and Brown, C.B., Darcy Flow Solutions with a Free Surface, Journal of Hydraulics Division, ASCE, Vol. 93 No. HY2, March 1967.

The inflows calculated provided a range of K_h/K_v values (ratio of horizontal to vertical permeability). The pre-grouting inflows tabulated by HEC in their 1975 report represents K_h/K_v values in the range of 10 to 500.

Figures VI-1, 2, and 3 show calculated inflow to the Mainstream Tunnel system based on the HEC data. Data from each borehole were applied to the tunnel for half the distance between boreholes. The values of inflow plotted represent those calculated with the presumptions that $K_h/K_v = 10$, thus, the figures are conservatively high. The average pre-grouting inflow to the Mainstream Tunnel system is estimated at about 0.5 MGD/mile.

Inflow projections for the Southwest intercepting sewer and the Calumet intercepting sewer indicated that pre-grouting total inflows at $K_h/K_v = 10$ would be about 0.9 MGD and 1.0 MGD, respectively. Observed inflow after construction and initial grouting of the Southwest sewer indicated that pre-grouting inflows were about 1.4 MGD. Reported pre-grouting inflow after construction of the Calumet sewer was about 0.7 MGD. Comparing predicted and observed inflow, HEC states "... the water pressure test results combined with the finite element computer program used give an accurate estimate of relative tunnel inflow and a reasonable, but generally low estimate of actual inflows."[1]

By studying the geohydrologic cross sections and analyzing pressure test data, the following can be concluded:

- On the average, sections of the Mainstream Tunnel which penetrate the Brainard shale exhibit an infiltration rate of about 0.001 MGD/mile or less.
- Infiltration from the Edgewood is approximately 0.012 MGD/mile; from the Joliet and Kankakee formations collectively, about 0.033 MGD/mile; and from the Racine formation, about 0.030 MGD/mile.

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[1] HEC, 1975.

FIGURE VI-1
Projected Inflow to Mainstream Tunnel
59th-to-Damen (1st Sampling)

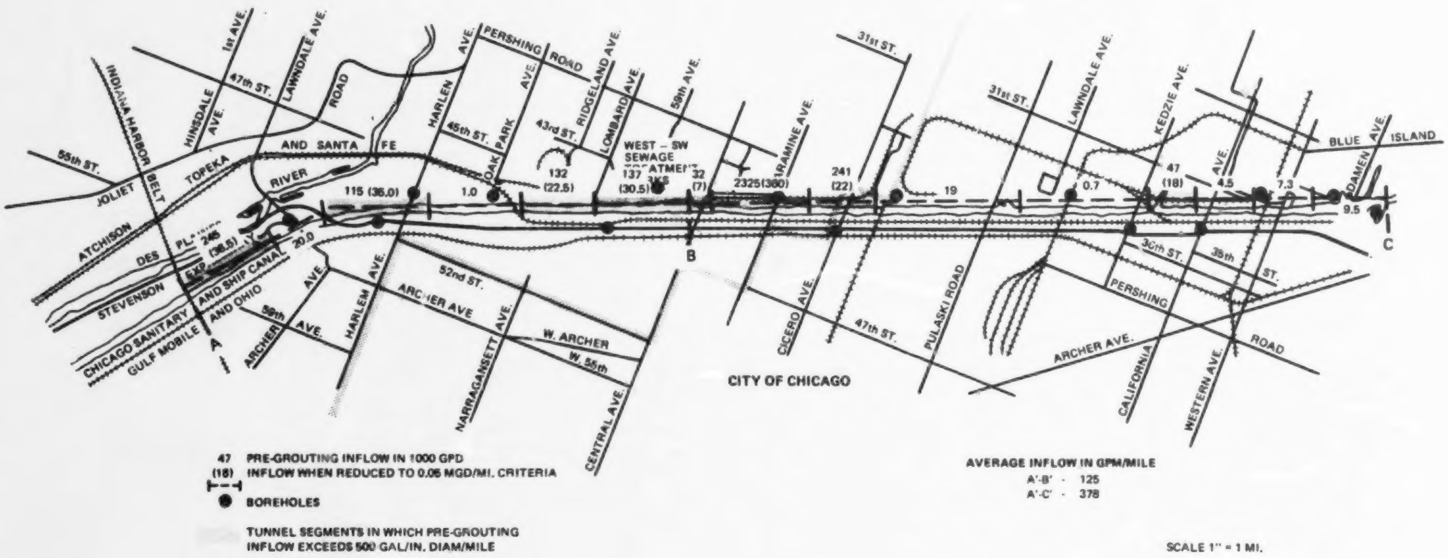

55th ST.
JOLIET
ATCHISON
INDIANA HARBOR BELT
HINSDALE AVE.
1st AVE.
47th ST.
LAWNDALE AVE.
ROAD
TOPEKA
AND SANTA FE
RIVER
DES PL
STEVENSON
EXP
CHICAGO SANITARY AND SHIP CANAL
GULF MOBILE AND OHIO
A
245
(36.5)
20.0
ARCHER AVE.
59th AVE.
HARLEM AVE.
HARLEN AVE.
115 (36.0)
1.0
PERSHING ROAD
45th ST.
OAK PARK AVE.
43rd ST.
RIDGELAND AVE.
LOMBARD AVE.
132
(22.5)
WEST – SW SEWAGE TREATMENT WKS
137
(30.5)
32
(7)
59th AVE.
52nd ST.
ARCHER AVE
W. ARCHER
W. 55th
NARRAGANSETT AVE.
CENTRAL AVE.
B
2325(360)
LARAMINE AVE.
241
(22)
CICERO AVE.
CITY OF CHICAGO
31st ST.
19
47th ST.
PULASKI ROAD
31st ST.
LAWNDALE AVE.
0.7
KEDZIE AVE.
47
(18)
AVE.
4.5
7.3
9.5
30th ST.
35th ST.
PERSHING ROAD
ARCHER AVE.
CALIFORNIA
WESTERN AVE.
BLUE ISLAND
DAMEN AVE.
C
47 PRE-GROUTING INFLOW IN 1000 GPD
(18) INFLOW WHEN REDUCED TO 0.05 MGD/MI. CRITERIA
● BOREHOLES
TUNNEL SEGMENTS IN WHICH PRE-GROUTING INFLOW EXCEEDS 500 GAL/IN. DIAM/MILE
AVERAGE INFLOW IN GPM/MILE
A'-B' - 125
A'-C' - 378
SCALE 1" = 1 MI.

FIGURE VI-2
Projected Inflcw to Mainstream Tunnel
59th-to-Damen (2nd Sampling)

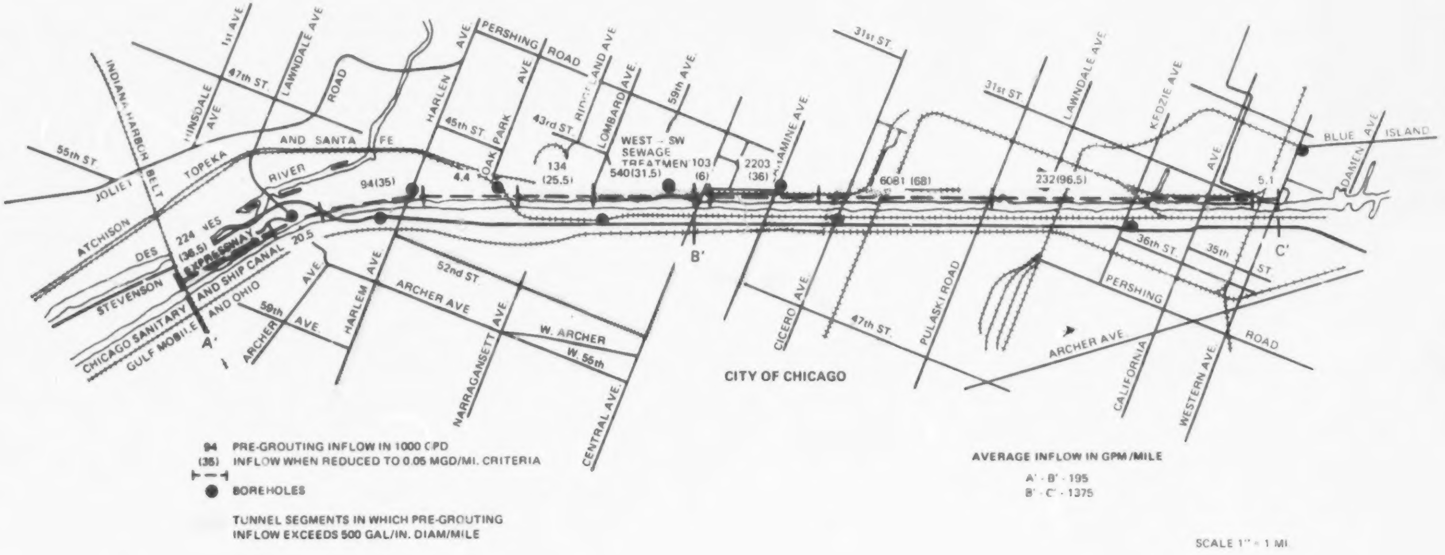
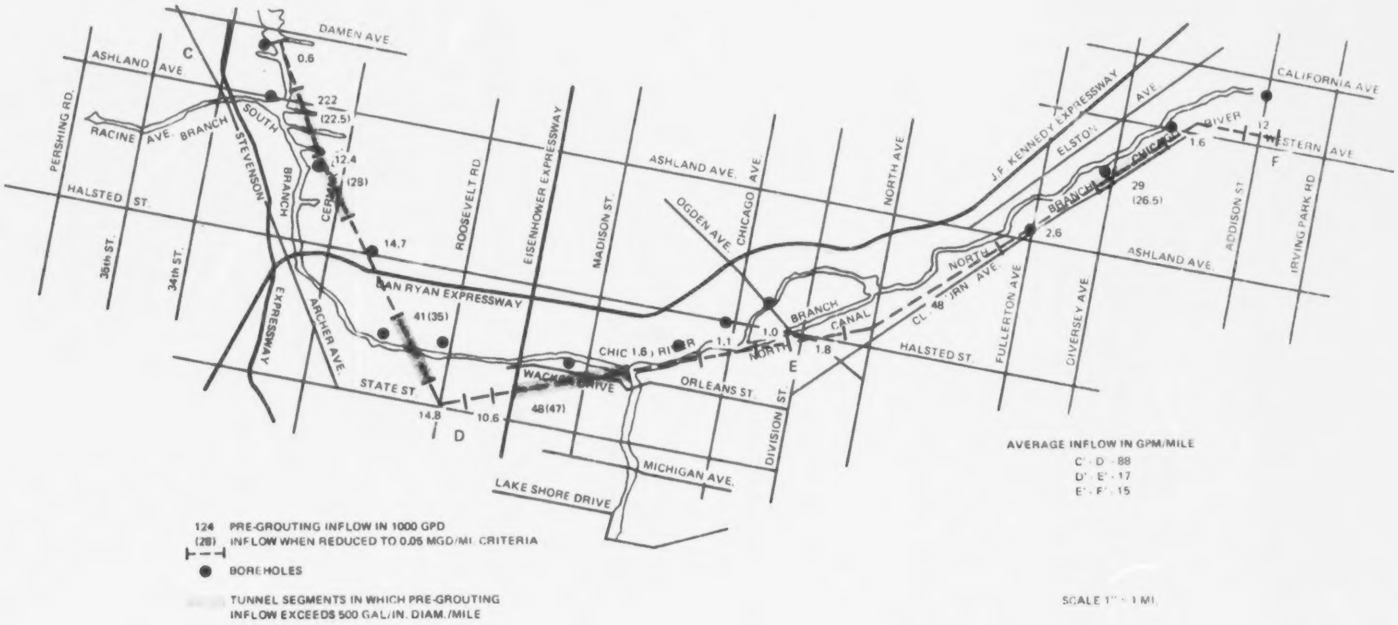

55th ST
INDIANA HARBOR BELT
JOLIET
ATCHISON
TOPEKA
AND SANTA FE
DES
RIVER
224
(36.5)
20.5
STEVENSON EXPRESSWAY
CHICAGO SANITARY AND SHIP CANAL
GULF MOBILE AND OHIO
A'
HINSDALE AVE
1st AVE
47th ST.
LAWNDALE AVE
ROAD
ARCHER AVE.
59th AVE.
HARLEM AVE
HARLEN AVE.
94(35)
4.4
45th ST
OAK PARK AVE
PERSHING ROAD
43rd ST.
134
(25.5)
RIDGELAND AVE
LOMBARD AVE.
59th AVE.
WEST - SW SEWAGE TREATMEN
540(31.5)
103
(6)
2203
(36)
LARAMINE AVE.
B'
52nd ST.
ARCHER AVE
NARRAGANSETT AVE.
W. ARCHER
W. 55th
CENTRAL AVE.
CITY OF CHICAGO
31st ST.
CICERO AVE.
47th ST.
6081 (68)
PULASKI ROAD
31st ST.
LAWNDALE AVE.
232(96.5)
KEDZIE AVE
AVE.
36th ST.
35th ST.
PERSHING ROAD
ARCHER AVE.
CALIFORNIA
WESTERN AVE.
5.1
C'
BLUE ISLAND
DAMEN AVE
94 PRE-GROUTING INFLOW IN 1000 GPD
(35) INFLOW WHEN REDUCED TO 0.05 MGD/MI. CRITERIA
● BOREHOLES
TUNNEL SEGMENTS IN WHICH PRE-GROUTING INFLOW EXCEEDS 500 GAL/IN. DIAM/MILE
AVERAGE INFLOW IN GPM/MILE
A' - B' - 195
B' - C' - 1375
SCALE 1" = 1 MI

FIGURE VI-3
Projected Inflow to Mainstream Tunnel
Damen-to-Addison


PERSHING RD.
35th ST.
34th ST.
HALSTED ST.
RACINE AVE. BRANCH
SOUTH BRANCH
STEVENSON EXPRESSWAY
ASHLAND AVE
C
DAMEN AVE
0.6
222
(22.5)
12.4
(28)
CERM
ARCHER AVE.
14.7
41(35)
DAN RYAN EXPRESSWAY
STATE ST.
14.8
D
10.6
48(47)
ROOSEVELT RD
EISENHOWER EXPRESSWAY
MADISON ST.
WACKER DRIVE
CHIC 1.6 RIVER
LAKE SHORE DRIVE
MICHIGAN AVE.
ORLEANS ST.
DIVISION ST.
OGDEN AVE.
CHICAGO AVE.
ASHLAND AVE.
1.1
1.0
NORTH
BRANCH
CANAL
E
1.8
NORTH AVE
CL 48 JRN AVE.
HALSTED ST.
J.F. KENNEDY EXPRESSWAY
ELSTON AVE
FULLERTON AVE
2.6
DIVERSEY AVE
NORTH BRANCH CHICAGO RIVER
29
(26.5)
1.6
12
F
CALIFORNIA AVE
WESTERN AVE
ASHLAND AVE.
ADDISON ST.
IRVING PARK RD
124 PRE-GROUTING INFLOW IN 1000 GPD
(28) INFLOW WHEN REDUCED TO 0.05 MGD/MI. CRITERIA
● BOREHOLES
TUNNEL SEGMENTS IN WHICH PRE-GROUTING INFLOW EXCEEDS 500 GAL/IN. DIAM./MILE
AVERAGE INFLOW IN GPM/MILE
C' - D' - 88
D' - E' - 17
E' - F' - 15
SCALE 1" = 1 MI.

- Where the tunnel is near the top of the bedrock, the permeability probably increases, therefore, the infiltration rate for the Racine is estimated to be 0.040 MGD/mile.

Due to the heterogenous nature of the aquifer, it is virtually impossible to predict specific locations and quantities of leakage that may be encountered during construction. Consequently, the exact dewatering requirements will only be found as construction proceeds.

(2) Dewatering

In view of the relatively low transmissivity (movement between two points) of the aquifer, dewatering at rates of several hundred gpm should result in minor temporary declines in local water levels. Average transmissivity values reported from tests in the upper aquifer range from about 16 gpd/ft to 30,150 gpd/ft. In areas of low transmissivity, the cone of depression that would result from dewatering would characteristically be deep, but of small diameter and steep sided. Conversely, in areas of higher transmissivity, cones of depression associated with dewatering operations would be of large diameter but shallow (small drawdowns) and with flat side slopes.

Pumping tests conducted by HEC[1] did not include data for a sufficient number of observation wells to enable construction of distance versus drawdowns graph; however, semi-quantitative evaluation of the data indicates that the radius of influence of pumping at 400 gpm for 156 hours (6.5 days) is probably less than 2 000 feet where calculated transmissivity is about 34,700 gpd/ft. In addition, the EPA reports that in the area of the Des Plaines-O'Hare System, "two pump-out tests performed in the course of the subsurface investigations failed to reflect any effect on observation wells as close as 75 feet away."[2] Due to the fractured nature of the bedrock and resulting heterogeneity, the cone of depression will most likely be asymmetrical. From this data it appears that dewatering of the tunnel during construction will have a minimal, temporary effect on the local groundwater regime.

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[1] HEC, 1975.

[2] EPA, "Final Environmental Impact Statement for the Metropolitan Sanitary District of Greater Chicago, Des Plaines-O'Hare Conveyance System," Chicago, Illinois, 1975.

(3) Water Quality

Tunnel grouting operations may result in clouding of groundwater drawn from nearby wells. If this occurs, alternative measures will be required to provide users of these wells with another water supply source. For the 59th-to-Addison Mainstream Tunnel segment, there are no water supply wells located near the tunnel route, and the clouding effect is not expected to occur.

6.1.3 Effluent Disposal From Tunnel Dewatering Operations

Infiltration of groundwater during tunnel construction can be expected, especially along fault zones and along the boundaries between different rock types. Where the infiltration rate is high, grouting operations will be carried out to limit the flow to the amount of conventional sewer infiltration, i.e., roughly 500 gallons per inch of tunnel diameter per mile per day. Water from grouting operations will add little to tunnel drainage flow. Maximum flow due to groundwater infiltration expected in the Phase I Mainstream Tunnel, from 59th Street to Addison Street, will be about 3.85 MGD after grouting.

Drainage water present in the conveyance tunnels may contain clay, concrete particles, grout waste, and other deleterious substances. Current MSDGC construction specifications[1] forbid the discharge from a construction site of drainage water containing these substances. Thus, drainage flow pumped from the tunnels will be held in settling tanks until rock, mud, grout material, and other solids settle and a water quality test has been performed prior to discharge to waterways. The tunnel contractor is required to dispose of settled solids in an environmentally safe manner although the method of disposal will not be identified until the preconstruction meetings with MSDGC.

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[1] MSDGC, General Specifications - Construction Contracts, Section 19, March 1974.

The disposal of effluent from dewatering operations during tunnel construction is expected to have a negligible impact upon the environment.

6.1.4 Water Management Programs

Construction impacts upon water management programs, identified in Section 2.1.4, are expected to be minimal. Most of the programs anticipate that construction of the tunnels and related facilities will avoid adverse interactions through proper planning.

The only water management program identified as having some potential for adverse interaction with tunnel construction is the 208 planning program. A major part of this program will be the in-stream monitoring of water quality parameters at 45 locations on the three major river systems. Inadvertent placement of a monitoring station in the immediate vicinity of a construction site could produce misleading data because of the discharge from tunnel drainage. This is not expected to occur, however, since the construction shafts for each tunnel segment have been identified clearly on reports available to the Northeastern Illinois Planning Commission (NIPC), the designated 208 planning agency.

Tunnel construction is not expected to interfere with navigation of the affected waterways since precautions will be taken to avoid discharge of sediment to these waterways. Therefore, tunnel construction is not expected to necessitate an increased frequency of waterway dredging by the U.S. Army Corps of Engineers.

6.2 LAND RESOURCES

The construction impacts of TARP on the land resources of the project area are discussed in detail in this section and divided into the following topics:

- Flood-Prone Areas
- Geology
- Seismicity
- Spoil Disposal.

6.2.1 Flood-Prone Areas

Construction of the Mainstream Tunnel system is not expected either to aggravate or to relieve problems in areas subject to overbank flooding. Construction of the tunnels, drop shafts, and collecting structure need to be completed before an effect is realized. Tunnel dewatering operations will be postponed during the rainfall episodes which may cause flooding.

6.2.2 Geology

Throughout the Chicago metropolitan area, an extensive program of subsurface exploration has been performed. After analyzing the information obtained, the conclusion has been drawn that the geological formations underlying the area are well suited to construction of underground conveyance and storage systems. The impact of construction on the Chicago area's seismic and subsurface geologic conditions should be negligible. The effect of the geologic conditions on construction is dependent on a number of interrelated factors and can be controlled by careful design and construction. The following effects are described based on the information presented in reports issued by Harza Engineering Company:[1,2,3] DeLeuw, Cather, and Company;[4,5,6] and Bauer Engineering, Inc.[7]

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[1] Harza Engineering Company (HEC), "Evaluation of Geology and Groundwater Conditions in Lawrence Avenue Tunnel, Calumet Intercepting Sewer 18E, Extension A, Southwest Intercepting Sewer 13A," Chicago, Illinois, 23 p., 1972a.

[2] HEC, Geology and Water Supply, "Technical Report Part 4, Development of a Flood and Pollution Control Plan for the Chicagoland Area," Metropolitan Sanitary District of Greater Chicago (MSDGC), Chicago, Illinois, 1972b.

[3] HEC, Geotechnical Design Report, "Tunnel and Reservoir Plan Mainstream Tunnel System," MSDGC, Chicago, Illinois, 1975.

[4] DeLeuw, Cather, and Company, "Southwest Side Intercepting Sewer 13A, Report of Tunnel Inspection," MSDGC, Chicago, Illinois, 1971.

[5] DeLeuw, Cather, and Company, Geotechnical Report on Upper Des Plaines Tunnel and Reservoir Plan, Vol. 1, "Bedrock Geologic Investigation," MSDGC, Chicago, Illinois, 196 p., 1974a.

[6] DeLeuw, Cather, and Company, Geotechnical Report on O'Hare Underground Storage Reservoir, MSDGC, Chicago, Illinois, 123 p., 1974b.

[7] Bauer Engineering, Inc., Environmental Assessment, MSDGC, Chicago, Illinois, 237 p., 1973.

A variety of factors control the interrelated impact of geology and construction. The geologic factors include: engineering properties of the rocks, rock structure variability, bedding attitude, presence of geologic structures (faults, folds, and joints) within each rock unit, and other occurrences such as the presence of natural gas.

(1) Geological Constraints

The physical aspects of the individual rock units define the impact that construction will have on subsurface geology and, conversely, the impact geology will have on construction. The engineering-geology aspects of the rock units are summarized in Table VI-1. General geologic aspects are discussed in Section 2.2.3, Geology.

1. Racine Formation

Tunneling excavation and support conditions are expected to be variable but satisfactory within the Racine formation, especially in the reef core facies.

Intensely fractured and faulted zones may require steel supports. The upper portion of the Racine is generally more permeable and less competent than the lower portion. Structures such as shafts may encounter weathered rock as they penetrate the upper portion of the formation. The interreef facies contains shale partings which crumble or disintegrate on exposure. The following possibilities should be considered in design and construction planning:

- Overbreakage may be fairly high in reef flank areas where the beds strike (trend) parallel to the tunnel line and dip at higher angles.
- Overbreakage will occur in unstable areas which normally are found with more frequency in fractured, weathered, and thinly bedded zones than in the more massive reef core facies.
- In the interreef facies the chert beds and nodules might create difficult local conditions of variable hardness.

Table VI-1
Engineering Geologic Characteristics of Rock Formations

Formation	Average Thickness (Feet)	RQD	Unconfined Compressive Strengths (PSI)	Tensile Strength (PSI)	Laboratory Drillability (feet/hour) 10'tunnel dia.	30'tunnel dia.	Special Features
Racine (Reef) Dolomite	117	>85%	1,770 - 24,230 35% > 10,000 53% = 5,000 - 10,000	590 - 24,230 Avg. 1,460 82% = 1,000-2,000	5.1 - 11.0	1.9 - 4.7	Minimum thickness near O'Hare increasing to maximum thickness near Lake Calumet. Occasional fracture zone. Deep weathering in upper 10-20 feet Occasional zones with slaking shale partings.
Racine (Inter-reef) Dolomite			3,390 - 28,050 55% > 10,000 40% = 5,000 - 10,000	190 - 3,210 Avg. 1,650 33% > 2,000 56% = 1,000-2,000			
Joliet (Romeo Mem.) Dolomite	11	>95%	5,770 - 32,920 92% > 10,000 53% > 20,000	730 to 3,420 60% = 2,000 to 3,000	5.7	2.3	Accumulation of water at contact with Racine.
Juliet (Markgraf Mem.) Dolomite	30	>95%	4,930 to 25,580 36% 10,000 to 25,000	600 to 2,940 80% 1,500 to 2,500	6.3	2.6	Lower zone with closely spaced shale partings, bedding plane parting, occasional fracture zone.
Joliet (Brandon Bridge Mem.) Dolomite & Shale	7	>95%	4,620 to 20,990	700 = 2,590	Not Available		Frequently absent but generally present in Des Plaines Valley. Deterioration of exposed units.
Kankakee Dolomite	43	Gen. >95%, some 53-75%	3,570 to 28,270 60% > 10,000	65% 1,500-2,000	6	2.5	Deterioration of shale partings. Some thin bedded zones.
Edgewood Dolomite	50	Commonly 95% Some 80-90% Rare 59-80%	2,800 - 25,580 65% >10,000 19% >15,000	1,070 - 2,710 93% 1,500-2,500	6	2.5	Cherty with variation in chert hardness, some prominent shaley zones. Thin bedded in lower portion.
Neda Shale Brainard Shale Shale	5 59	>80%	1,760 - 8,650*	340 - 1,150*	10	4	High tendency to slake, least satisfactory rock. Brainard absent in portions of Calumet section. Neda frequently absent.
Fort Atkinson Dolomite w/Shale	17		9,130 - 14,430	890 - 2,160	5	2	Deterioration of occasional shale interbeds.
Scales Shale	96		8,520*	600 - 1,320	10	4	Slaking & stress release breakage. Becomes soft & plastic when wet.

---

* Considered not representative of in situ properties. Not useful for predictions of actual construction conditions.

- Differences between the unconfined compressive strengths of reef and interreef rock could also create local conditions of variable hardness.
- Zones containing numerous shale partings will slake.

2. Joliet Formation - Romeo Member

The uniform, tough, dense character of the Romeo member should make it good material for underground construction, except in fractured zones where excessive groundwater may be encountered and where steel support and/or concrete lining may be required.

One potential problem associated with the Romeo member is the possible accumulation of groundwater at the upper contact where the Racine overlays the unit.

The consistency of engineering-geology characteristics would indicate generally satisfactory tunneling conditions. Rockfall and overbreakage should be minimal except in intensely faulted or jointed areas.

3. Joliet Formation - Markgraf Member

Aside from fractured zones where concrete lining and/or supports may be necessary, and where greater quantities of groundwater may be encountered, the Markgraf should prove to be a satisfactory rock for underground construction.

The soft condition of the chert in the upper zone may be slightly troublesome for machine tunneling. The shale partings of the lower zone do not appear to slake badly.

The Lawrence Avenue, Southwest, and Calumet Tunnels have been constructed principally in the Joliet formation. Although little short-term support has been required to stabilize these unlined tunnels, the rock has a tendency to break along its flat bedding planes which will affect future tunnels in the Joliet formation, under the projected operating conditions.

4. Joliet Formation - Brandon Bridge Member

This member is absent from most of the project area and, therefore, is not considered as a subsurface site for underground features. If it is found, the shale content of the rock will detract from the suitability of the Brandon Bridge member for construction of underground facilities. Although this member is uniformly thin-bedded, overbreaks were rarely reported in previous tunneling projects.

5. Kankakee Formation

Preliminary study of the Kankakee formation suggests that the rocks may have a number of properties that would detract from their suitability as a medium for underground construction. The potential difficulties include overbreaks and groundwater control problems, which could become important where rocks are severly fractured. Most difficulties will be associated with the numerous green shale partings characteristic of the formation, especially in its lowest 15 to 20 feet. The formation has several thin-bedded zones.

6. Edgewood Formation

Wherever the Edgewood formation is badly fractured, groundwater inflow may be heavy. This formation, however, is good rock for tunneling. The upper part is less argillaceous, less laminated, and has softer chert, thus, it will be better than the lower part which is more argillaceous, contains harder chert, and is more closely laminated.

Machine tunneling through the lower parts of the Edgewood may be impeded by the chert nodules and lenses, which are up to four inches thick, combined with the increasing frequency and thickness of shale partings and the gradation of the rock to dolomitic shale.

Another significant problem which will be encountered tunneling through the Edgewood formation and the underlying Brainard shale is the irregularity of the contact between the two formations. The contact is somewhat more irregular than it is shown on the geologic sections. Thus, predicting conditions at elevations or levels near the contact will be variable and subject to a large error.

7. Neda and Brainard Formations

Together with the Neda shale above and the Scales shale below, the Brainard shale has a tendency to slake, which makes it the least satisfactory rock of the project for underground construction.

The Brainard and Neda exhibit pronounced slaking and crumbling in rock core samples which are exposed to the atmosphere or placed under water. There may also be some stress-relief phenomena present. Pronounced slaking will lead to serious impairment of rock strength. The dolomite interbeds are not subject to slaking or disintegration.

Since shale has a tendency to slake, and possibly to swell with the atmosphere, it will be necessary to take remedial actions as soon after exposure as possible to control these phenomena. In these rocks, plastic strain is expected to occur throughout significant lengths of excavation. It would be extremely difficult to position a significant length of tunnel in the Brainard formation because of its variable thickness.

8. Fort Atkinson Formation

In highly fractured zones in this formation high water inflows may occur. Where relatively massive and pure, the Fort Atkinson dolomite should make good tunneling rock. Where shale interbeds are frequent, their deterioration by tunneling would weaken the rock mass and short-term support would be necessary until concrete lining could be provided for long-term stability.

9. Scales Formation

As in the Brainard formation, the Scales shale exhibits pronounced slaking and crumbling.

This will seriously impair rock strength. The rock core samples of the Scales formation become soft and plastic when wet. This evidence, as well as experience with shales, suggests the possibility of plastic flow in portions of this unit. Slaking has occurred during construction of storage caverns partly excavated in the Scales in northern Illinois and Indiana.

The geologic constraints on construction are only partially related to rock type. Additional impediments which have some impact on construction include faults, folds, and joints.

1. Faults

A number of fracture, or fault, zones have been mapped (Figures II-22 through II-26). Within the Mainstream Tunnel area, these zones are found near Chicago Avenue, Roosevelt Road, and Lawndale Avenue. Along the Des Plaines Tunnel system faults have been mapped near 26th Street, Roosevelt Road, North Avenue, and Irving Park Road (not located in drilling). Additionally, the Des Plaines Tunnel will pass through the southern and western sections of the Des Plaines structure, a zone of multiple and complex faulting. The Calumet Tunnel systems are expected to encounter faulting near Little Calumet Creek and State Street, Little Calumet Creek and Cottage Grove, Dalton Avenue, Torrence, 118th Street, 109th Street, 107th Street, and Burnham Avenue. Additional faults have beem mapped in recently constructed tunnels. As stated in Section 2.2.3, faulting with small vertical displacement is common in the Chicago area and numerous small faults should be expected throughout the proposed tunnel systems.

Faulting is expected to have several types of impact on tunnel construction. Fault zones may be accompanied by brecciation of the rock or may be marked by the presence of fault gouge or mylonite. These zones, as zones of inherent weakness in the tunnel roof and walls, pose a concomitant danger of an increase in rock fall. The faults are planes of movement which may cause abrupt rock structure changes during tunneling operations.

Such abrupt strata changes may alter tunnel excavation rates as well as increase (or decrease) the potential of overbreakage and rockfall.

2. Folds

The folds in the Chicago region are quite gentle and generally have east-west trends. Folding should have only indirect impact on construction. The structural characteristics involved in folding have raised or depressed various rock layers in relation to a horizontal plane or line. The tunnels will, thus, pass through different rock layers because of folding. Within the Mainstream Tunnel system, prominent rock layer changes due to folding are expected to occur between Touhey and Devon, Irving Park and Diversey, Roosevelt and Pulaski, and Oakton and Dempster.

3. Joints

Joints are widespread throughout the rocks in the Chicago area and may have an impact on construction where:

- The tunnel is parallel to the joint orientation
- Complimentary joint sets or joints of varying orientation intersect
- Intense weathering or alteration has occurred along joint planes
- Joints abruptly change dip angle or horsetail in passing from one lithologic unit to another.

The above features of joints would result in local instability and would increase the potential for rockfall and overbreakage during tunneling.

Another possible hazard would be encountering natural gas. If ignited, the resulting fire or explosion could damage equipment and cause loss of life. Such gas accumulations could be found in the glacial drift or in the rock mass itself. In the Chicago area, the presence of gas has been reported in drilling operations in the glacial drift; and asphaltum, a solid petroleum residue, has been found in rock strata of the Racine formation. Such conditions indicate the possibility of encountering accumulations of gas, though the probability is believed remote. Gas detection devices, of course, must be used during construction as a safety precaution.

(2) Construction Constraints

In addition to the effects of geologic phenomena on construction, various facets of construction may have an impact on geologic features. These effects are considered to be negligible or easily mitigated by sound design and construction procedures.

Those operations which could affect the geology of the area are: subsurface exploration, either core drilling or seismic; drop or access shaft construction; mined or machine excavation for tunnel or underground storage; and surface excavation. Except for subsurface exploration by seismic means, all of these operations would entail material removal.

Seismographic exploration of subsurface soils and strata utilizes sound waves to detect varying densities of material. Sound is reflected at those levels or strata where change occurs. This procedure would have negligible effect on the geologic features. For core drilling exploration, drill holes are filled after tests have been completed to prevent interflow between aquifers.

The effects of construction activities on the geologic conditions may include the following:

- Subsurface collapse
- Joint or fault weathering and alteration
- Induced motion along faults or fault zones
- Rockfall or overbreakage
- Surface landsliding or erosion.

While subsurface collapse through rockfall is possible, machine-excavated tunnels may require support to prevent such failure of the surrounding soil or rock. For much of the tunnel lengths, the rock cover

over the tunnel crown is considered to be sufficiently thick and structurally sound to preclude widespread collapse.[1]

Weathering or alteration along joint planes or faults, due to the introduction of fluids or exposure to the atmosphere, is expected to be a minor phenomena during the construction stage. Such alteration is further dependent on the characteristics of the rock layers traversed by the tunnels. The excavation stages are probably short enough so that alteration along the joints will be locally restricted in the susceptible shale units.

Fault motion induced by tunneling operations (blasting, moling, etc.) which includes rockfall or overbreakage, is considered possible but unlikely.

Surface excavation for reservoirs and construction of drop and access shafts could lead to subsidence of adjacent lands, as well as pronounced erosion.

Under carefully controlled conditions and proper construction procedures, the construction phase of the project should have no pronounced impact on the geologic conditions in the Chicago area.

6.2.3 Seismicity

Seismic characteristics of the Chicago area, found in the historical earthquake record, include frequency, magnitude and probability of occurrence, and potential seismic events. These characteristics have been described in detail in Section 2.2.4.

The risk of the tunnel construction being impaired by earthquakes is judged to be small, based on an evaluation of this historical record. As Figure II-29 of Section 2.2.4 shows, the recurrence rate for a Modified Mercalli Intensity (MMI) VIII event is about once for every 100 years with longer intervals for higher intensities. Insofar as the record can be relied upon to indicate the level of future seismicity, these higher intensities would not be expected to occur during construction.

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[1] Bauer, 1973.

Considering the record of local seismicity, however, the faults in the project area should be assumed to be potentially active. In a seismic event, two types of potential tunnel damage could result:

- Dislocation of the tunnel along a fault
- Rock falls along faults or joints.

General rock fall, which is unrelated to existing breaks, or the formation of new cracks is unlikely.

As discussed in Section 2.2.4, ground motion producing an MMI of VIII can be expected from a local earthquake with a recurrence period of about 100 years. This local earthquake will be generated by small movements on a fault (a few centimeters). If the causative fault intersects the tunnel system, the minor dislocation may offset the tunnel alignment. Rock fall in the vicinity of such a dislocation may be extensive. Ground motion from a local earthquake may also cause extensive rock fall in the tunnel wherever multiple joints or faults are present. Both the impact of tunnel dislocation along a fault, with the likely associated local rockfall, and general rockfall along joints throughout the tunnel system caused by vibratory ground motion depend greatly on the distribution and nature of faults and joints. Insufficient information is available on these subjects to make a valid judgment of potential damage. The assessment of impacts depends on a slight upward revision in the possible intensities of past local earthquakes and cognizance of the imprecision of epicentral locations. The occurrence of a large earthquake, however, during the construction phase of the tunnel systems is not likely.

The probability of fault motion or seismic events being caused or controlled by construction procedures, based upon experience from the already existing tunnels, is also considered to be small. No seismic events associated with faults exposed to blasting, water influx, or rock falls have been reported during previous tunneling projects.

6.2.4 Spoil Disposal

This section outlines the environmental impacts associated with the disposal of rocks and spoil material excavated from the proposed tunnels and reservoirs. The amounts of spoil material involved and the likely methods of disposal are identified for the TARP system as a whole and separately for the Mainstream Tunnel system. Spoil volumes produced by reservoir construction are discussed here to provide a proper perspective to the spoil disposal problem and to indicate the full extent of the impacts associated with the spoil disposal.

In general, rock excavated from the McCook and Thornton quarries, to form the proposed storage reservoirs, is expected to be equal to rock presently excavated for commercial purposes at two sites. Uses for this material include use as concrete aggregate and as fill for such projects as the "Ski Mountain" plan.

Rock excavated from the tunnels, however, is only expected to be suitable for low-grade commercial uses and for fill. This assumption is based on past experience with spoil produced from the MSDGC's Lawrence Avenue Tunnel, a deep tunnel situated in the same rock formation as the proposed tunnels will be. Moled rock from the Lawrence Avenue Tunnel was not considered suitable for use as concrete aggregate because the material contained a sufficient quantity of shale and other constituents not compatible for aggregate use.

It is the MSDGC's stated policy that construction contractors shall be responsible for the disposal of material excavated from each Phase I tunnel segment. The MSDGC's expectation is that the contractors will either find markets for excavated materials or will utilize suitable, environmentally acceptable waste disposal sites. Since actual disposal plans will not be identified until the preconstruction meeting between the contractor and the MSDGC, the disposal schemes outlined in this section are only speculative. It is assumed for the purpose of this analysis that the contractors will sell marketable spoil as fill material whenever possible and dispose of nonsaleable spoil at area landfills. The marketability of the spoil is affected by the amount of shale and other non-dolomite constituents present in the material.

(1) Tunnel and Reservoir Plan

Excavation of the Phase I tunnels and the proposed reservoirs at McCook and Thornton quarries will produce a bulk measure of approximately 275,000,000 cubic yards (183 million cubic yards solid measure) of spoil material. About 165,000,000 cubic yards of the total will be generated in the excavation of the reservoirs at McCook while about 92,000,000 cubic yards will be produced at the Thornton quarry excavation site. Construction of Phase I tunnels will generate roughly 17,620,000 cubic yards of spoil material for disposal. A detailed plan for the disposal of this considerable amount of material has not yet been developed. However, the general disposal scheme which will be adopted is likely to be as follows.

1. Reservoirs

Rock excavated from either McCook or Thornton quarry is likely to have much the same commercial value as rock currently quarried, because the excavation will be done by conventional methods rather than by mole machines. It is expected, therefore, that a large portion of the excavated rock will be stockpiled in another area of the quarry for eventual sale. Unuseable rock will be either stored in a separate stockpile on-site, as is planned for McCook quarry, or stockpiled off-site, as is proposed for Thornton quarry.

Sufficient room for stockpiling of reservoir spoil exists at the McCook quarry and neighboring sludge lagoons. The required acreage varies with the allowable height of the stockpile. Alternatives considered to date for stockpile size range from 298 acres for a 600-foot-tall pile, which could be entirely contained by the quarry site, to 770 acres for a 100-foot-tall stockpile. A 770-acre site is presently not available in the Chicago area. The existing sludge lagoons, which could be a possible site if expansion is allowed, are not expected to be expanded for storage purposes. The eventual height of the stockpile is expected to be limited by air traffic safety considerations. The Federal Aviation Agency has indicated preliminarily that the maximum elevation of stockpiles in the McCook area would be limited by air traffic constraints to about 200 feet above street grade. To limit stockpile height to 200 feet, approximately 600 acres would be needed for spoil storage. This would be available at designated disposal areas of the McCook site, assuming some utilization of neighboring MSDGC sludge lagoons for a small amount of additional storage.

2. Tunnels

Spoil generated by tunnel construction is expected to be disposed of by landfilling. However, the landfill sites and storage capacities have not been identified as yet. The chemical composition of the spoil material, largely dolomitic limestone with some shale is not likely to cause problems with groundwater contamination by leachate from the spoil.

Excavation of all Phase I tunnel systems over the ten-year period from 1976 through 1985 will produce approximately 17,620,000 cubic yards of rock and soil for disposal, weighing about 26 million tons. Peak production of spoil material is expected to occur in 1980 when approximately 2,162,000 cubic yards (solid measure) of rock will be excavated. Assuming a bulking factor (ratio of volume of spoil produced to the volume of rock mined) of 1.5, at the peak of construction, contractors must dispose of roughly 3,243,000 cubic yards of material. By assuming that the volume of spoil material produced is roughly proportional to construction expenditures over the ten-year period[1] for the Phase I tunnels, one obtains the spoil production rates shown graphically in Figure VI-4.

The environmental effects associated with such a plan are primarily emissions to the atmosphere from truck traffic and truck noise. These atmospheric effects are evaluated in Sections 6.3.1 and 6.3.2, respectively, of this chapter. Other potential impacts on the natural environment, such as groundwater contamination by leachate, are not likely to occur due to both the stable nature of the spoil and the degree of isolation from the environment provided by landfill operations.

(2) Mainstream Tunnel System

Excavation of the Phase I Mainstream Tunnel from 59th Street to Addison Street over the ten-year period from 1976 through 1985 will produce approximately 4,540,000 cubic yards (bulk volume) of spoil for

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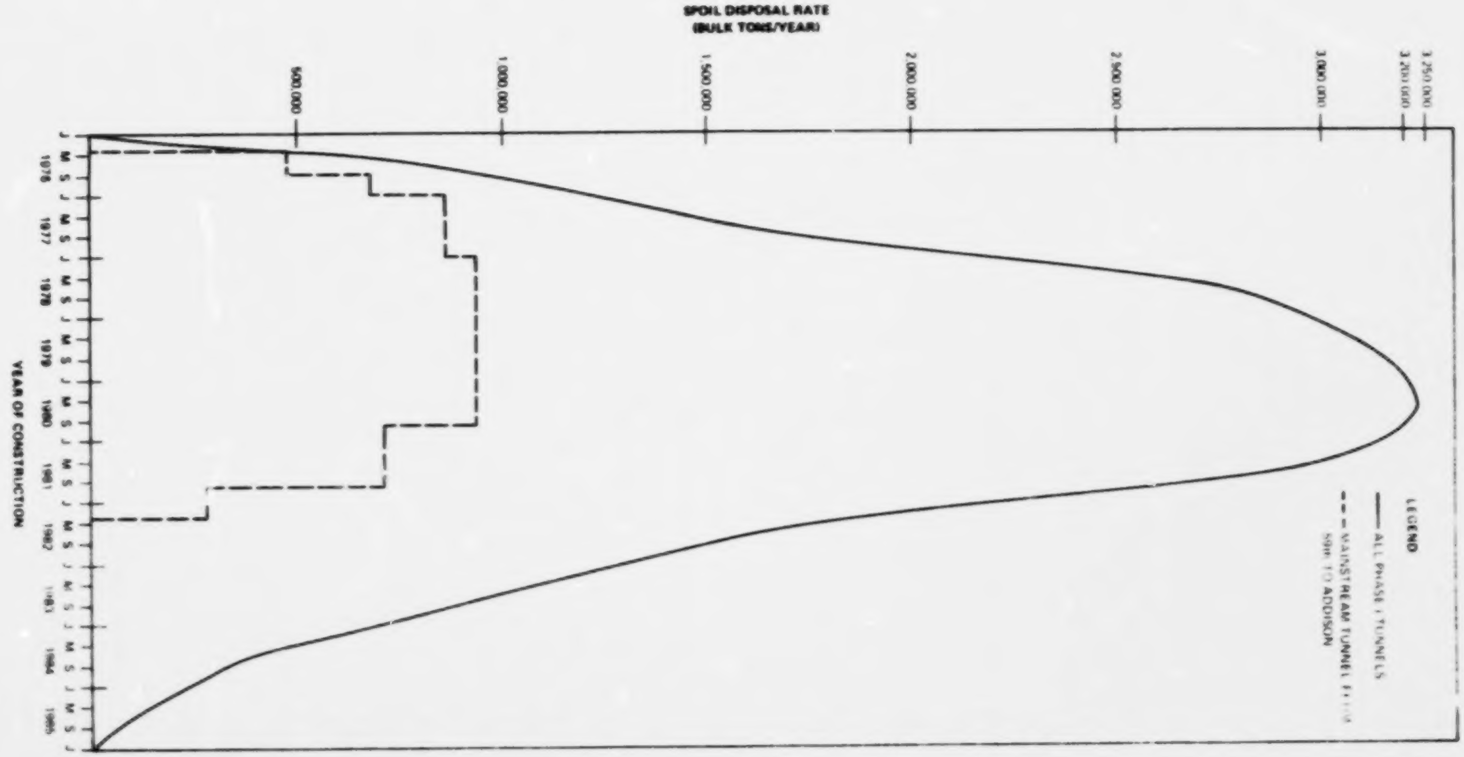
[1] See Table III-11, p. III-21.

FIGURE VI-4
Spoil Production Rates for Phase I
Tunnel Plan and for
Mainstream Segment



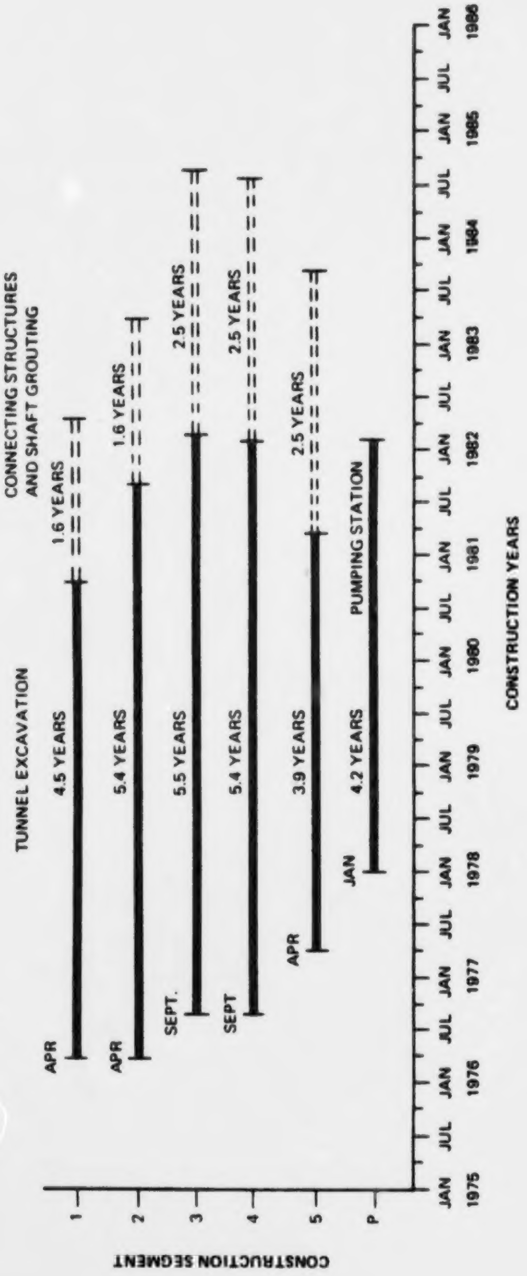
disposal weighing about 6,743,000 tons. Peak generation of spoil material is expected to occur over the period from January 1978 to October 1980 when the rate of spoil generation will reach 941,000 cubic yards per year. This figure assumes the excavation of 627,300 cubic yards per year and a bulking factor of 1.5. Spoil production rates were calculated from the MSDGC's construction schedule for the Mainstream Tunnel system from 59th Street to Addison Street shown in Figure VI-5. Spoil production rates for the Mainstream Tunnel system are compared with production rates for all the Phase I tunnels in Figure VI-4. In the absence of information concerning the contractor's specific disposal plans, it is assumed that spoil material from the Mainstream Tunnel system will be disposed of in landfills. One potential site for the disposal of a significant amount of spoil from the Mainstream Tunnel system is the inactive Stearns quarry. The quarry has an available capacity of about 6.5 million cubic yards to street level. Once filled to this grade, the site could be used for a park or for some other function. A comparison of the volumes involved shows that the Stearns quarry could easily accept all of the spoil generated by construction of the Mainstream Tunnel system from 59th Street to Addison Street. Possible truck routes to the Stearns quarry from Mainstream Tunnel construction shafts are shown in Figure VI-6. Other potential sites include the Techny landfill and the Septon landfill, although available capacities are not known.

The significant impacts associated with spoil disposal from the Mainstream Tunnel system are:

- Land use implications of filling in the Stearns quarry
- Emissions to the atmosphere from truck traffic
- Noise from trucking operations.

Section 7.2.2 evaluates the impact on land use resulting from filling in the Stearns quarry. Impacts on air quality and noise levels resulting from truck disposal operations are detailed in Sections 6.3.1 and 6.3.2, respectively, of this chapter. Other potentially serious impacts upon the natural environment, such as groundwater degradation by leachate, are not likely to occur due to both the stable nature of the spoil and the degree of isolation from the environment provided by landfill operations. Marketability of the spoil will be limited because of the amount of shale and other undesirable constituents present in the material.

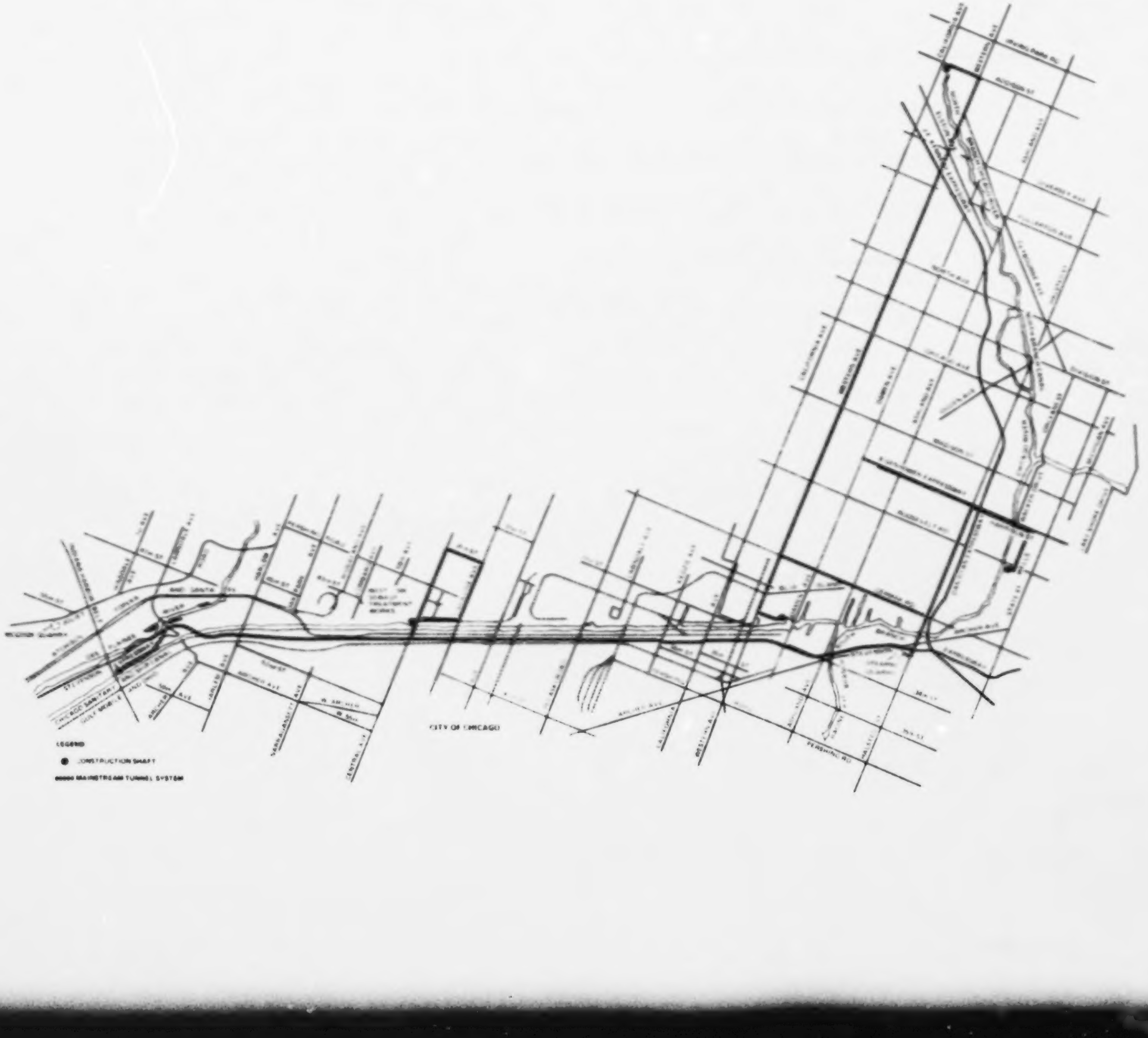
FIGURE VI-5
Construction Phasing for
Phase I - Mainstream
Tunnel System



LEGEND

TUNNEL SEGMENT	SPOIL VOLUME (CUBIC YARDS, BULK)
1 – 59th TO CENTRAL	1,017,000
2 – CENTRAL TO DAMEN	1,391,000
3 – DAMEN TO ROOSEVELT	1,124,000
4 – ROOSEVELT TO OGDEN	668,000
5 – OGDEN TO ADDISON	
P – PUMPING STATION	342,000
TOTAL	4,542,000

FIGURE VI-6
Truck Routes to the Stearns Quarry from
Mainstream Tunnel Construction Shafts



CITY OF CHICAGO
LEGEND
● CONSTRUCTION SHAFT
MAINSTREAM TUNNEL SYSTEM
ARCHER AVE
NARRAGANSETT AVE
CENTRAL AVE
HARLEM AVE
CHICAGO SANITARY AND SHIP CANAL
DES PLAINES

6.3 ATMOSPHERIC RESOURCES

The effects of construction on air quality and noise are discussed in the following section.

6.3.1 Air Quality

Construction of the proposed tunnel would have a minor impact on ambient air quality. The impact would result from air pollutants emitted by construction-related vehicles and equipment and would occur at the construction and drop shaft sites and along the vehicle routes. The impacts at the various locations are discussed below.

(1) Construction Shaft Site

The principal source of air pollutants at a construction shaft site would be exhaust from trucks used to haul rock and spoil material from the site to disposal sites. In addition to an estimated three to five truck trips per hour, construction workers would add approximately 54 car trips per day and concrete trucks may make one trip per hour. Diesel-engine-operated equipment may also emit air pollutants at the site. They include the trolley used for transporting rocks inside the tunnel, air compressors for supplying air to the tunnel, and the crane used for raising the muck carts to the surface. The total emissions from the above sources would be very small, and would have negligible impact on ambient air quality.

Another potential source of air pollution would be dust generated when loading the muck from hoppers into into trucks and when driving the trucks on unpaved roads. However, with appropriate mitigating measures as discussed in Chapter X, the dust problem can be controlled.

(2) Drop Shaft Site

The sources of air pollutants at the drop shaft site would be similar to those at the construction shaft site. However, because of the fewer number of vehicles involved, there would be less impact. Also, the impact would be relatively short-term, since the construction of a drop shaft is not likely to last for more than three months.

(3) Vehicle Routes

The construction-related vehicles would emit pollutants when traveling to and from the construction sites. While the routes taken by the commuting workers would vary, the hauling trucks would follow well-planned routes. The most likely truck routes for the Mainstream system are shown in Figure VI-6.

Vehicle emissions would generally depend upon the vehicle miles traveled (VMT) and can be estimated by multiplying the VMT by suitable emission factors.

For the Mainstream system, the average daily number of truck trips originating from all the construction shaft sites and traveling to the proposed disposal sites is estimated at about 250, with an average round trip length of 11.5 miles. Therefore, the average daily VMT by the haul trucks to be used in the Mainstream system would be about 2,900. The number of truck trips during the peak construction period in 1980 is expected to be twice the average number. The truck emissions are estimated using the peak year VMT and emission factors, and are shown in Table VI-2.

Table VI-2
Estimated Emission From Rock and Spoil Disposal Trucks, 1980

Pollutant	Emission Factor[1] (gm/mi)	Estimated Emissions (kg/day)
CO	28.7	82.2
HC	4.6	13.3
NO_2	20.9	60.6
SO_2	2.8	8.1
TSP[2]	1.3	3.8

[1] For heavy-duty diesel trucks from, Compilation of Air Pollutant Emission Factors, Supplement No. 5, AP-42, U.S. Environmental Protection Agency, April 1975.

[2] Total suspended particulates.

The estimated truck emissions are very small compared to those occurring from normal vehicular traffic on the proposed routes. Therefore, their impact on ambient air quality is likely to be insignificant. Similarly, the incremental and cumulative impacts from the concrete truck trips and worker trips are not likely to be significant. The cumulative impact from vehicle trips originating from the other two tunnel systems is also likely to be minor.

6.3.2 Noise

Adverse noise impacts during construction of the proposed project would occur primarily during surface excavation at the construction and drop shaft sites and during transportation of the rock and spoil material along the routes to the disposal sites. Since most of the construction and drop shaft sites in the Mainstream Tunnel system would be located in commercial or industrial areas, noise impact at the construction site is not likely to be significant. Similarly, noise impact of rock and spoil disposal trucks would not be significant, because the number of truck trips generated by the proposed project generally would be small compared to the existing traffic volume on the most likely truck routes to the disposal sites.

In this section, noise impact is discussed as follows:

- Noise at the Construction Shaft Sites
- Noise at the Drop Shaft Sites
- Noise Along the Truck Routes.

(1) Noise at the Construction Shaft Sites

Construction activities at the site of a construction shaft can be divided into three phases.

Phase 1 consists of excavating the soil to the depth of the bedrock, which is generally 20 to 25 feet below the surface. This operation typically lasts for two to three months. This operation uses conventional excavation equipment, such as a clam bucket. The spoil material would be hauled by trucks to suitable disposal sites at a frequency of one to two trucks every two hours.

Phase 2 involves blasting the rock with dynamite to the depth of approximately 300 feet. Approximately 400 feet of the initial section of the tunnel would also be blasted. This operation may last for about six months. Rocks would be removed by trucks in the same manner as the soil.

Phase 3 involves finishing the shaft walls and excavating the tunnel by mole. The rock from the tunnel would be brought to the surface and taken in trucks to suitable disposal sites at a frequency of about three to five trucks per hour. This operation would last about four years at the Roosevelt Road shaft and about 5.5 years at the Damen Avenue shaft.

Assuming that two trucks and one loader operate simultaneously at the construction site, and that their maximum noise levels, at 50 feet, are 86 dBA in accordance with the Chicago noise ordinance, the cumulative noise levels near the construction site would vary from 91 dBA at 50 feet to 61 dBA at 1600 feet.

If exhaust fans are used for tunnel ventilation, the exhaust noise is likely to vary from about 75 dBA at 50 feet to about 50 dBA at 1600 feet.[1] The noise from the mole and from blasting are not likely to be heard at the surface. Since all of the construction shafts are located in areas which are relatively isolated from the general public, the construction noise impact at the construction shaft site is not likely to be significant.

(2) Noise at the Drop Shaft Sites

The construction period at the site of a drop shaft is shorter than that at the construction shaft site. The soil is excavated in a manner similar to that at the construction shaft site. A small pilot hole is then bored to the depth of the tunnel, which is already excavated. The entrance from drop shaft to tunnel is excavated by blasting. The drop shaft is then bored by means of a raise drill, which is raised from the bottom to the surface. The muck is collected at the bottom of the tunnel and transported internally to a construction shaft. Only soil, no rocks, would be transported from the drop shaft site.

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[1] Based on the noise from ventilating fans used in a traffic tunnel. Environmental Research and Technology, Inc., Noise Level Analysis for Interstate 95 Fort McHenry Harbor Crossing and Approaches in the City of Baltimore, Maryland, prepared for the State Highway Administration, November 1974, p. F-12.

The construction at a drop shaft site would probably last for only three months. However, surface noise would be produced primarily during surface excavation. Surface excavation is not likely to last for more than a few weeks. Thus, the noise impact would be short-term at the drop shaft sites.

As previously stated, most of the drop shaft sites in the Mainstream system are located in business/commercial and industrial areas where noise impact is not as severe a problem as it is in residential areas. Appropriate measures to mitigate the noise at sites near all public areas are discussed in Chapter X.

(3) Noise Along the Truck Routes

On probable truck routes to the rock and spoil disposal sites, the existing traffic volumes range from 13,000 vehicles per day to 118,000 vehicles per day. The number of truck trips generated at each construction shaft site is likely to be between 72 to 120 per day. The number of truck trips generated during the peak construction period, involving construction of the three tunnel systems, would be approximately 575 per day. However, these trips would be spread over several routes. Thus, the incremental truck trips resulting from tunnel construction would be very small compared to existing traffic volume on the haul routes. Consequently, the noise impact from additional truck trips is not likely to be significant.

6.4 COMMITMENT OF RESOURCES

Approximately 11,750,000 cubic yards (solid measure) of dolomitic rock will be removed from several geologic formations within the Silurian system during the Phase I construction period of TARP. This volume is equivalent to 26,200,000 dry tons, assuming an in-place rock density of 165 pounds per cubic foot (4,455 pounds per cubic yard). The distribution of this total amount between the three tunnel systems is: 5,750,000 cubic yards (12,800,000 dry tons) from the Mainstream Tunnel system, 2,960,000 cubic yards (6,590,000 dry tons) from the Des Plaines Tunnel system, and 3,040,000 cubic yards (6,770,000 dry tons) from the Calumet Tunnel system. The average removal rate of rock throughout the ten-year construction period will be 1,175,000 cubic yards (2,620,000 dry tons) per year for all systems of TARP.

VII. EFFECTS OF CONSTRUCTION ON THE MAN-MADE ENVIRONMENT

VII. EFFECTS OF CONSTRUCTION ON THE MAN-MADE ENVIRONMENT

The effects of construction activity during the proposed tunneling project on the man-made environment are discussed in this chapter. Only primary and significant effects are presented.

This chapter is divided into five main sections:

- Socioeconomic
- Land Use
- Financial Resources
- Transportation
- Major Projects and Programs.

7.1 SOCIOECONOMIC

The socioeconomic section describes effects of the projected construction activity evidenced by public annoyances and inconvenience, worker safety, construction income and economic multiplier effect within the community, description of business activity and impact on the area labor force.

7.1.1 Public Annoyances

Major construction projects in urbanized areas usually generate conditions which are considered annoying, and which can create public inconvenience. The Tunnel Plan involves construction activities which will necessarily reach disparate parts of Cook County unlike single-site construction projects. Construction of the tunnels will involve the following major activities:

- Construction of surface collection facilities
- Removal of pavement
- Excavation of trenches
- Blasting

- Replacement of necessary sewer lines

- Construction of access, drop, and construction shafts

- Haulage of debris and spoil material

- Exhaust and air support system operations.

The major annoyances and public inconvenience that are associated with the above construction activities include:

- Noise and vibration effects
- Dust and dirt
- Traffic congestion and disruption
- Glare from night lighting.

Since much of the tunneling is performed by machines at depths of up to 290 feet below ground, the annoyances to the general public are temporary and, to a great extent, can be lessened through application of mitigating measures. Effects of noise and fugitive dust have been discussed in detail in Chapter VI and effects of construction traffic congestion are discussed in 7.4.

(1) Glare From Night Construction Activity

Glare from night lighting at construction access points can be annoying to surrounding residents. This annoyance can be reduced by properly positioning the lights away from surrounding properties.

(2) Vibration Effects

Construction of the construction access and drop shafts will require some blasting operations. The vibration effects of blasting can potentially cause structural damage to residential homes if the velocity exceeds 4 inches per second. Engineered structures can generally withstand 10 to 20 inches per second.

The blasting operations while creating vibrations also create noise. The average person's psychacoustic response to the combined vibration and noise generally intensifies the import of the blast without making the important distinction between motion and sound.

In addition to the reaction to motion and sound effects, people are sensitive to the duration of a project and the frequency and time of blasting. More complaints and/or claims will be made the longer the project lasts, the more often blasting takes place, and if there is blasting during the night or quiet hours.

Because of their concern over possible property damage, people are more sensitive to blasting when they are in their own homes. They are less interested and less concerned when occupying buildings in which they have no financial interest but are still annoyed by the noise. Possible exceptions would be those persons engaged in especially delicate work.

With a well-planned operation, there is no need for blasting effects to be either damaging, frightening or of an unacceptable tolerance level. First of all, the MSDGC can make certain that no structural damage will occur by placing blasting limitations in the project's construction specifications. Secondly, further reductions in the allowable limits can be made to make the blasting less noticeable (usually not very cost effective) or take steps to keep the public sufficiently informed so that observers of the blasting will have no cause for alarm and will be willing to accept some minor irritation in return for the benefits which the project will bring to the community.

The blasting need only occur during the day and will be of a short duration. Estimated duration periods for both construction and drop shafts are stated below:

Construction Shaft - 2 blasts per day, 10 seconds per blast for 90 to 120 days.

Drop Shaft - 3 blasts per day, 10 seconds per blast for 3 to 5 days.

The blast vibrations and noise generated during the construction of the Mainstream Tunnel system may be annoying to the public within 250 to 500 feet of the shaft locations, but should not cause any structural or physical damage to properties nearby.

(3) Construction Locations Which May Cause Public Inconvenience

Review of the proposed locations for construction access shafts and drop shafts in connection with the Mainstream Tunnel plans indicates several locations of potential conflict with public convenience. The construction access shafts have purposely been placed in areas where there should be no conflict with surrounding properties. Generally, the sites are vacant, already owned by the MSDGC, and surrounded by vacant or low-utilization industrial areas.

Several drop shafts, shown in Table VII-1, have been identified as potential locations of conflict with local vehicular and pedestrian traffic because of their proximity to a surface street or intersection. The shaft diameters range from 4 to 17 feet, and additional maneuvering space will be required for equipment and workers, as well as for the erection of safety barriers and equipment. This might mean that portions of the shoulders and possibly traffic lanes temporarily would be blocked to traffic. A few drop shafts appear to be located in parking or storage lots which would mean loss of some parking spaces or rearrangement of stored items. Of the 82 drop shafts reviewed, 22 appear to present potential conflicts; of these, 16 are located in the downtown Chicago area. This is not surprising and will require exercising particular care in the placement of equipment, materials, and safety barriers, as well as a well-coordinated traffic control plan. Since precise locations of shafts are not known at this time, it is difficult to predict the amount of inconvenience to the public.

7.1.2 Worker Safety

Worker safety and prevention of accidents during TARP construction and throughout maintenance and operation of the completed systems requires adherence to all applicable regulations of the OSHA Act. Much of the system construction involves underground drilling, moling, and blasting; therefore, the establishment of surface support and communications systems for workers underground are critical. Scheduling of underground work must also be sensitive to weather conditions.

Table VII-1
Drop Shaft Location Posing Potential Conflict Conditions[1]

Drop Shaft Number	General Location	Shaft Diameter	Comment
30	W 1200 Block of W 35th Street	7'2"	May block a lane and shoulder
34	2600 Block of S Ashland Street	4'	May eliminate some parking spaces
37	2300 Block of S Halstead Street	4'	In an industrial parking lot, may use spaces
41	2100 Block of S Canal Street	9'	May block a lane and shoulder
52	300 Block of W Quincy Street	9'	May block a lane and shoulder
53	Jefferson & Monroe Streets	13'	May block a portion of the intersection
54	NE Corner of Wacker & Franklin	9'	May block a lane and sidewalk
55	N Side of Wacker 100' E of Mich Ave Bridge	9'	May block a lane, bridge, historic interest
56	NE Corner of Wacker Drive & Stetson Ave	4'	May block a lane and shoulder
57	NE Corner of Wacker & Columbus	5'8"	May block a lane, just N of IL Center
58	NW Corner of Lake Shore Drive & E Lake Shore Drive	9'	May block a lane and sidewalk
59	N Water Street 50' W of Lake Shore Drive	4'	May block a lane and sidewalk
60	N Water across Road E of St Clair Street	12'	May block a lane and sidewalk
61	W Kinzie Street between Kingsbury & River	9'	May eliminate parking spaces in lot
62	Chicago Ave & W Bank of North Branch	4'	May eliminate some spaces in parking lot
63	N Halstead and W Bank of North Branch	4'	May eliminate some spaces in parking lot
64	N Elston Between Cortez & W Division Street	13'	Location in boat yard's storage lot
67	NW Corner of W Haines Street & N Branch Canal	4'	Location in N Chicago freight yards-industrial area
71	1600 Block North Ave near Dock	7'2"	Potential traffic problem at dock
72	End of Clifton Ave at N Branch	4'	May block a lane and shoulder
79	Logan St & W Diversey Intersection	13'	Surrounded by residential properties
84	West Roscoe St and N Branch	13'	Location in boat yard storage lot

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[1] MSD Tunnel and Reservoir Preliminary Plans - "Photo Plan Maps From Aerial Photographs Taken January 25, 1973," Photo Control From USGS 7 1/2 Foot Quadrangle Sheets, March 1974.

The MSDGC construction specifications include an extensive section regarding safety requirements found in the general specifications for their construction contracts. In addition to compliance with OSHA, the contractor must comply with the following regulations:

- Safety Rules - Metropolitan Sanitary District of Greater Chicago of March 1, 1970 and as amended
- The Illinois Health and Safety Act of March 16, 1936 with all amendments thereto and all rules and standards implementing said act.

Safety engineers must approve and maintain the following safety equipment for tunnel and excavation work:

- Adequate stretcher units convenient to work locations
- Oxygen deficiency indicators
- Carbon monoxide testers
- Hydrogen sulfide detectors
- Portable explosimeter for the detection of explosive gases such as methane, petroleum, and vapors
- An adequate number of U.S. Bureau of Mines approved self-rescuers in all areas where employees might be trapped by smoke or gas
- An explosimeter at each heading to monitor continuously the presence of explosive gases; it must automatically provide visual and audible alarms.

The contract specifications also require all power equipment used underground to be certified and operated according to OSHA regulations.

Even with strict safety precautions during the construction period, accidents and injuries will occur. Table VII-2 shows the incidence of injuries which could be expected based on national injury frequency rates for 1974 within the construction industry. These rates are somewhat conservative when applied to specific construction projects, but can provide a minimum scale of expectation. As shown, the Mainstream Tunnel construction potentially could experience a minimum of 90 disabling injuries and one fatal or permanent disability case during its seven years of construction.

Table VII-2
Potential Work Injuries and Disabilities Related to Mainstream Tunnel Construction[1]

Total Man-hours of Exposure for Mainstream Tunnel*	Potential Disabling Work Injuries†	Potential Fatal and Permanent Disabilities††
6,356,173	90	1

* Metropolitan Sanitary District of Greater Chicago.

† Frequency rate of 14.18 per million man-hours of exposure.

†† Frequency rate of .16 per million man-hours of exposure.

[1] Frequency rates from Accident Facts, 1975 Edition, National Safety Council, Chicago, Illinois, p. 35.

A less conservative estimate can be made by reviewing the safety statistics of other tunneling projects. The Washington, D.C. Metro (subway) construction project has had 45 miles of tunnels and 41 stations under construction since 1970. They also have been using moles for most of the tunneling work. Based on 45 million total construction man-hours, they have experienced eleven (11) fatalities and 1,829 cases of lost time due to injury. They have not broken out injuries, disabilities, and deaths for tunneling *per se*. While the man-hour estimates are not comparable, the miles of tunnels give a relative measure; approximately one death for every 4.09 miles, and approximately 41 injuries every mile. Using these measures for Mainstream's 57 miles of tunnels would yield a speculative maximum of 14 fatalities and 2,337 work-related injuries. This level of incidence is certainly too high for Mainstream Tunnel construction alone, and is only mentioned an an example of an underground construction project's safety record. Worker safety during the maintenance and operation phase will also involve adherence to OSHA and State of Illinois safety standards, particularly as they pertain to underground inspection and repair work.[1]

7.1.3 Construction Income

The construction of the Mainstream Tunnel system will inject construction employment income into the Chicago area economy. Estimates of this income and of the secondary effect of this income or economic multiplier effect can also be calculated. The income injected into the Chicago area economy due to construction employment on the Mainstream Tunnel system will generate a direct demand for goods and services resulting in additional employment opportunities. (See Table VII-3).

This impact is commonly referred to as nonbase or secondary employment and it is generated through the salaries and profits derived by the employees and the business created in response to the identified direct demand. The extent of secondary impacts that will occur in any given situation is dependent on a complex set of factors concerning the local economy. Essentially, the extent of secondary impact is effected by the proportion of dollars that remain in the economy under examination. Dollars would not remain in the economy, for example, if the products purchased through direct demand had been manufactured outside of the subject economy. In this example, the dollar cost of the product would escape generating employment elsewhere; only the value added in the local economy would generate local employment.

Given the diverse economy of the Chicago area, it is quite possible that a high proportion of goods and services will be purchased locally. Thus, the dollars spent for construction could potentially circulate in the local economy two to three times. We have attempted to estimate this secondary impact through the selection of an economic multiplier which is then applied against direct construction employment income. We have used a multiplier of 1.8 which indicates that a significant proportion of direct expenditures will remain within the local economy.

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[1] Washington Metropolitan Area Transit Authority, "Accident Experience Summary," December 1975.

Table VII-3
Estimated Jobs Generated By Industry[1]

Fiscal Year	Mainstream Construction Cost in Millions	Manufacturing*	Wholesale Trade and Transportation, Services*	Mining and Other*
1976	$16.6	185	86	43
1977	$54.9	613	286	144
1978	$76.9	859	401	201
1979	$91.4	1021	477	239
1980	$96.7	1081	504	253
1981	$90.2	1008	470	236
1982	$51.8	579	270	135
1983	$18.2	203	95	47
1984	$ 8.6	96	44	22
1985	$ 2.9	32	15	7
1986	-	-	-	-

* Derived by utilizing the following jobs per billion dollars of contract construction: 40,523 total, 11,180 for manufacturing, 5,220 for wholesale trade transportation and services, and 2,623 for mining and other.

[1] "BLS Unpublished Data," Bureau of Labor Statistics, U.S. Department of Labor, February 1975.

Table VII-4 presents construction and labor cost estimates for tunnel construction only by segment of the Mainstream system. Table VII-5 presents construction employment income estimates by segment by year during the construction period and the secondary effect of the income in the local economy.

The assumptions inherent in the calculations are that one man-year equals 2,000 man-hours, and that the average man-hour cost is $10.95. The economic multiplier used is 1.8. As shown, the peak construction man-loading would occur in the years 1978, 1979, and 1980. Construction income would reach $18.2 million with a secondary economic effect of $32.7 million within the Chicago area economy. Contract construction earnings in the Chicago region in 1971 totaled $2,055.4 million, or $2.0 billion.[1] The Mainstream Tunnel project, at its peak, would represent less than 2 percent of total area construction earnings based on the 1971 reported earnings level. Construction employment earnings from this one project are not considered overly significant in the perspective of the Chicago region's economy.

Related to construction earnings is the number of construction jobs which would be generated by the Mainstream tunneling project. Table VII-6 shows job generation by year based on the construction and man-hour estimates previously established by segment by year. Job generation would range from 320 jobs in 1976 to a peak of 831 in 1978 and 1979, thereafter declining to 68 in 1982, the last year of construction. The low level of job generation is due to the use of boring machinery (moles) in tunneling. Should the moles prove inefficient or ineffective during the construction period, it is quite likely that additional jobs would be generated when conventional blasting and cutting methods are employed as partial backup.

Construction projects also generate jobs in other industries; primarily manufacturing, wholesale trade, transportation and services, mining, and others. Table VII-3 shows the generation of jobs in other industries based on total cost of construction of the Mainstream system. These jobs can be located anywhere depending upon the materials and services bought and the natural chain of production.

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[1] Table III-5, Chapter III, p. III-6.

Table VII-4
Tunnel Construction and Labor Cost Estimates By Segment of the Mainstream System[1]

Mainstream Segment	Total Construction Estimate*	Estimated Labor Cost	Estimated Man-Years Needed	Estimate of Construction Duration (Years)
59th to Central	$ 48.6	$12.6	575	4.5
Central to Damen	$ 69.3	$18.0	820	5.4
Damen to Roosevelt	$ 65.7	$17.1	775	5.5
Roosevelt to Ogden	$ 45.3	$11.8	535	3.9
Ogden to Addison	$ 54.9	$14.3	650	5.4
Pumping Station	$ 78.1	$14.7	670	4.2
Total	$361.9	$88.5	4025	-

* Expressed in millions of dollars; materials and labor costs involved in tunneling only.

[1] Metropolitan Sanitary District of Greater Chicago.

Table VII-5
Mainstream Tunnel Construction Income
(in millions)

Mainstream Segment	Construction Years 1976	1977	1978	1979	1980	1981	1982	1983	1984
59th to Central	2.8	2.8	2.8	2.8	1.4	-	-		
Central to Damen	2.4	3.3	3.3	3.3	3.3	2.4	-		
Damen to Roosevelt	.8	3.1	3.1	3.1	3.1	3.1	.8		
Roosevelt to Ogden	-	2.0	3.0	3.0	3.0	.8	-		
Ogden to Roosevelt	1.0	2.6	2.6	2.6	2.6	2.6	.3		
P Station	-	-	3.4	3.4	3.4	3.4	.4		
Total	$ 7.0	$13.8	$18.2	$18.2	$16.8	$12.3	$ 1.5	-	-
Secondary Effect*	$12.6	$24.8	$32.7	$32.7	$30.2	$22.1	$ 2.7	-	-

* A multiplier of 1.8 has been applied.

Table VII-6
Mainstream Construction Job Generation

Year	Construction Income	Construction Man-Hours*	Construction Job Generation†
1976	$ 7,000,000	639,269	320
1977	$13,800,000	1,260,274	630
1978	$18,200,000	1,662,100	831
1979	$18,200,000	1,662,100	831
1980	$16,800,000	1,534,246	767
1981	$12,300,000	1,123,288	562
1982	$ 1,500,000	136,986	68
1983	$ -	-	-
1984	$ -	-	-
1985	$ -	-	-
1986	$ -	-	-
Total	$87,800,000	6,356,173	-

* Based on an average usage of $10.95 per hour.

† Based on 1 man-year = 2,000 man-hours. Estimates provided by Metropolitan Sanitary District of Greater Chicago.

7.1.4 Business Disruption

Construction site activity and attendant truck traffic in densely developed commercial retail areas can disrupt operations of local businesses. If public traffic flow is impacted, business deliveries and services can be hurt. This has varying degrees of effect on sales depending on the business's response to adverse conditions.

Table VII-1 in Section 7.1.1 identified those construction access points where potential conflict with public traffic flow is most likely to occur. Of those points, there are several located in or near commercially developed areas.

The following locations potentially could cause inconvenience to surrounding business operations. However, the disruption would be temporary and should not cause significant negative impacts on business activity and retail sales volumes.

Shaft Number	Shaft Diameter	Location
52	9'	300 block of W. Quincy Street
54	9'	N.E. corner of W. Wacker and N. Franklin
55-58	4'-9'	Along the river bank north of Wacker Drive between Michigan Avenue Bridge and Lake Shore Drive
60	12'	N. Water access road east of St. Clair Street

Estimates of the land needed surrounding a drop shaft are as follows:

- 150' x 150' for average drop shaft of 7'2" or less in diameter
- 200' x 200' for larger drop shafts up to 13' in diameter.

Construction of the drop shafts may take approximately three months. When built, the shaft will have a concrete cover, flush with grade, with a metal grate for access by workers (similar to a manhole). Both the grate and cover can bear pedestrian and vehicular traffic. The trucks servicing the construction sites have been purposely routed along major surface streets to expressways to minimize traffic flow interruption. The impact of these additional trucks in the downtown area is not considered significant enough to create permanent adverse impacts on business activity. No business structure will have to be acquired or demolished.

The only relocation needs are related to piles of material in certain industrial yards which may have to be moved and boats in the two boat yards open-storage areas. Thus, the effects are considered temporary and insignificant.

7.1.5 Spoil Disposal

This section addresses the potential impact of disposal of spoil from the tunnel construction and reservoir excavations on the local markets for high quality rock products (e.g., concrete aggregate, siluminous aggregate, etc.) and low quality rock products (primarily landfill).

(1) Tunnel Spoil

It is estimated that the construction of the Phase I TARP tunnels will produce almost 12 million cubic yards (approximately 26 million tons) of excavated material from the Mainstream, Des Plaines, and Calumet Tunnel systems over a ten-year period. The potential impacts of disposing of this volume of spoil critically depends on the quality of the material removed. The focal point of the quality assessment is a comparison of the geological characteristics of the TARP tunnel spoil with those characteristics of the spoil generated from the construction of the Lawrence Avenue Sewer system.[1]

The tunneling technology which is planned for the Tunnel Plan was also employed by the city of Chicago in the recent Lawrence Avenue Sewer project. Approximately 350,000 tons of dolomite limestone containing some shale rock were excavated during the course of the project. Similarly, the material that will be excavated from the TARP tunnels and drop shafts will also be dolomite limestone with shale. As shown in Figure V-3, the Lawrence Avenue material comes from the same geological formation and would yield rock spoil identical to that which will be excavated for the construction of the TARP tunnels.

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[1] This system was recently constructed to accomodate combined sewer overflows and to act as an interceptor for the proposed Mainstream Tunnel system.

Utilization of the mole (mechanical mining machine) produces rock spoil which is thin and elongated rather than cubical in shape. Typical sizes of excavated rock range from fine dust particles to laterally split rocks which are about two to five inches in cross section and 1/2 to 3/4 inches in thickness. In the case of the Lawrence Avenue project, it was initially assumed that the rock spoil could be marketed as concrete aggregate and/or road base material. It was discovered, however, that the excavated rock material contained shale and failed to meet Illinois standards for use in these categories. As a consequence, this material was primarily used as low quality landfill. Shale present in the material tends to lower the quality and thus, limit the marketability or uses.

Experience with the Lawrence Avenue system strongly suggests that the primary use for excavated materials from the TARP tunnels will be for landfill. This conclution is further supported by the experience of a major major quarry operator in the Chicago Metropolitan area who had to abandon efforts to market this type of material because it could not be crushed and refined in a manner that would meet industry standards for high quality rock products.

Since there are no reliable current estimates of the demand for landfill in the local area over the period 1976 to 1986, it was not possible to develop reliable expected sales estimates of the excavated material from the TARP tunnels. Therefore, although there will be no significant economic impacts on the markets for high quality rock products, a definite conclusion concerning the market for landfill cannot be reached at this time.

In the worst case, where the demand for landfill is satisfied by the existing supply, the excavated material may have to be stored or simply disposed of. However, proposed plans, such as the Lakefront and Ski Mountain plans, can utilize the material should these plans be implemented. Storage and disposal of rock spoil is analyzed in Section 6.2.4.

(2) Reservoirs

As described in Section 6.2.4, spoil produced during excavation of the reservoirs is likely to be retained in stockpiles at the McCook and Thornton quarries under the ownership of the quarry operators. Release of this material on the market will probably be at the discretion of the quarry operators. Thus, no significant socioeconomic impacts are expected.

7.2 LAND USE

The proposed tunnel system would make efficient use of land resources for several reasons. First of all, the chief structural components, which are the tunnels and pumping stations, would be located underground. Second, maximum use has been made in the plan of existing combined sewers and interceptors, minimizing the need for interceptor connections and drop shafts in the plan. Third, MSDGC property has been utilized for shaft locations wherever possible to lessen the need for access easements and purchase of private properties. Fourth, the system would convey overflows to existing treatment and sludge handling facilities, at the West-Southwest Sewage Treatment Works plant, which also uses MSDGC-owned land. Fifth, rock and spoil from construction would be disposed of at approved sites. Sixth, requirements for new access roads to surface construction sites have been minimized by locating shaft sites close to existing roads. Finally, all shafts would be located as close to the river bank as possible, so that nearly all of the shafts would make use of land which is prone to overbank flooding. This land is of relatively low value.

Because of the tunnel system's efficient use of land, the potential impacts on land use during construction are few. Detailed analysis of land use impacts follows under the following subsections:

- Alterations Near Surface Construction
- Rock and Spoil Disposal
- Archeological and Historical Sites
- Cultural and Recreational Sites.

7.2.1 Alterations Near Surface Construction

The construction of 82 drop shafts, 2 access shafts, and 5 construction shafts would require adequate space around the shafts for manuevering trucks and construction equipment, for storing of equipment, and for mobile offices where required. The area needed at drop shaft and access shaft sites would be a maximum of about 10,000 square feet, or less than one-fourth of an acre for the largest shaft, which is 13 feet in diameter. Space requirements for smaller shafts would be less. Each of these areas would be used over a period of about three months.

Construction shafts would be located on MSDGC land and would each require several acres of land during construction, over periods of from four to five and one-half years. Acreages used at the five construction shaft sites would be:

Shaft Number	Location	Acres
2	59th Street	7.0
3	Central Avenue	7.0
4	Damen Avenue	7.0
5	Roosevelt Street	3.7
6	Addison Street	3.5

All of these sites are located on MSDGC land except for shaft number 5, at Roosevelt Street, which must be purchased by the MSDGC from a private owner.

For the part of the tunnel which follows the North Branch Table VII-7 shows: land use at the proposed sites of drop shaft numbers 61 to 85, the number of shafts in each use, and the associated impact during construction.

Table VII-7
Land Use Distribution and Impact for
Drop Shafts 61 to 85

Land Use[1]	Number of Drop Shafts	Impact on Land Use
Industrial yard	7	Temporary reduction in materials handling capacity
Industrial parking	6	Temporary consumption of parking space
Vacant public and MSDGC property	4	None
Street edge	2	Temporary reduction in traffic capacity
Boat storage yard	2	Temporary reduction in storage capacity
Materials storage yard	2	Temporary reduction in storage capacity
Dock	1	Temporary reduction in storage capacity

[1] MSDGC Tunnel and Reservoir preliminary plans - photos plan maps from aerial photographs taken January 25, 1973. Photo control from USGS 7½-foot quadrangle sheets, March 1974.

All of the effects are temporary and do not actually change land use, but constitute minor interruptions to the utilization of land at the drop shaft sites.

A construction shaft would also be excavated along the North Branch section of the tunnel route. It would be located south of West Addison Street and east of the North Branch in a vacant MSDGC-owned tract of land. The location of the shaft would be about 500 feet from the most remote part of the Lane Technical High School, and its construction is not expected to cause interference with the utilization of school property.

For the tunnel section which follows the Main Branch of the Chicago River, Table VII-8 gives land use of the proposed locations for drop shaft numbers 54 to 60, number of drop shafts in each use, and associated impact during construction.

Table VII-8
Land Use Distribution and Impact for
Drop Shafts 54 to 60

Land Use[1,2]	Number of Drop Shafts	Impact on Land Use
Prepared base for future Riveredge Esplanade Park (currently vacant)[3]	4	Temporary reduction in traffic capacity on lower level of Wacker Drive between Michigan Avenue and Lake Shore Drive
Street edge	2	Temporary reduction of traffic capacity on North Water Street
Vacant land at river edge	1	Temporary reduction of traffic capacity on lower level of West Wacker Drive at North Franklin Street

[1] MSD Tunnel and Reservoir preliminary plans - photos plan maps from aerial photographs taken January 25, 1973, photo control from USGS 7½-foot quadrangle sheets, March 1974.

[2] All are public lands.

[3] Part of planned pedestrian walkway for the Illinois Center project.

The only effects on land use along the Main Branch would be temporary interference with the existing traffic flow. The change in land use which would result from construction would be the conversion of vacant publicly-owned land to environmental protection use.

Drop shaft numbers 23 to 53 would be located along the South Branch. Land uses at the shaft locations, number of shafts in each land use type, and impact on land use are shown in Table VII-9.

Table VII-9
Distribution of Land Use and
Impact for Drop Shafts 23 to 53

Land Use[1]	Number of Drop Shafts	Impact on Land Use
Industrial yard	11	Temporary reduction in materials handling capacity
Vacant	7	Conversion of vacant land to environmental protection use
Industrial parking	5	Temporary consumption of parking space
MSDGC property	4	Conversion of vacant public land to environmental protection use
Materials storage yard	1	Temporary reduction in storage capacity
Street edge	3	Temporary reduction in traffic capacity

[1] MSD Tunnel and Reservoir preliminary plans - photos plan maps from aerial photographs taken January 25, 1973, photo control from USGS 7½-foot quadrangle sheets, March 1974.

Any impacts along this portion of the tunnel route can be expected to be slight, because current utilization of industrial properties generally is not intensive. The potential for traffic disruptions is addressed further in Section 7.4.

Construction shaft number 5 at Roosevelt Avenue would consume 3.5 acres of sparsely used industrial yard after purchase by the MSDGC from a private owner. The construction of this shaft would remove a relatively low value industrial parcel from private use and convert it to environmental protection use. The supply of surrounding land with similar value would not be significantly affected.

The remaining drop shafts, two construction shafts, and two access shafts would be constructed near the banks of the Sanitary and Ship Canal. Land uses, numbers of drop shafts in each use, and associated impacts are given in Table VII-10.

Table VII-10
Distribution of Land Use and Impacts for
Drop Shafts 4 to 22

Land Use[1]	Number of Drop Shafts	Impact on Land Use
Vacant MSDGC property	10	Conversion of vacant public land to environmental protection use
Industrial yard	5	Temporary reduction in materials handling capacity
Industrial parking	3	Temporary consumption of parking space
Materials storage yard	1	Temporary reduction in storage capacity

[1] MSD Tunnel and Reservoir preliminary plans - photos plan maps from aerial photographs taken January 25, 1973, photo control from USGS 7½-foot quadrangle sheets, March 1974.

The effects on industrial land uses would be slight, because adequate land is available to shift existing operations as required. Two construction shafts would be located in this part of the route; one at 59th Street and the other at Central Avenue. Both would require the use of about seven acres each of MSDGC-owned land, which is currently vacant and is surrounded by vacant or little-used land. The resultant land use impact would be conversion of vacant public land to environmental protection use.

Two access shafts would be constructed; one near Pulaski Avenue and the other near South Cicero Street. Both sites are vacant MSDGC-owned land near the banks of the canal.

Construction of the shafts would require building several access roads and improving two existing access roads. The new roads would have the following lengths and locations:

- 500 to 750 feet, connecting construction shaft number 6 to Addison Street
- 50 to 100 feet, connecting drop shaft number 83 to Rockwell Street on Melrose Avenue

- 500 feet, extending 20th Street to construction shaft number 4.

Road improvements would probably be required on: the existing 4,000-feet-long access road along the Sanitary and Ship Canal from Laramie Avenue to the site of construction shaft number 3, and the 4,000-feet-long road along the canal from Lawndale Avenue to the site of construction shaft number 2. All of the new and the improved roads would be on MSDGC property and land use would be compatible with adjacent land uses. Certain easements would also be required during construction which together would total 3.86 acres.[1]

In summary, the impacts on land use would be temporary during surface construction of the Mainstream Tunnel system. These impacts are primarily consumption of a small amount of valuable industrial property and reduction of traffic capacity for periods of about three months at each of a few drop shafts.

7.2.2 Rock and Spoil Disposal

The active and inactive quarries in the area may be used to store and dispose of rock and spoil materials excavated during construction. No other possible storage and disposal sites have been identified. Excavated material from the Mainstream system should not change or interfere with the current use of these quarries.

7.2.3 Archeological and Historical Sites

(1) Archeological Sites

The lands which have the highest potential for containing material of archeological value to be disturbed during construction are the banks of the North Branch and the Main Branch of the Chicago River. Although no archeological sites or materials are known to exist there, these areas have been actively used for commerce since the late 1700's and earlier by the Potawatomi Indians who hunted, traded furs, and occasionally camped in these areas. Because little is known about the use of the area prior to settlement by Europeans, any archeological finds in the lands along the North Branch and the Main Branch, on which shafts will be constructed, could have high potential value.

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[1] MSDGC, February 4, 1976.

Fortunately, the conventional methods of surface excavation planned for shaft construction would probably allow adequate recovery of any archeological finds. In fact, the net impact is likely to be favorable, because more archeological material of value would likely be recovered than destroyed. The mitigating measures in Chapter X would help to ensure this result.

The storage and handling of rock at McCook quarry would have no impact on archeological resources, because the land there has already been disturbed.

Construction of shafts along the South Branch and the Sanitary and Ship also would not be likely to result in archeological finds or losses, because the lands along these waterways have been extensively disturbed during river straightening and canal excavation.

(2) Historical Sites

There would be no interference with any designated or pending-designation type historical sites, since all surface construction is located at a sufficient distance from the sites. Moreover, the only historical sites within 500 feet of surface construction are the markers of already lost sites. The closest construction to a marker would be drop shaft number 55. The shaft would be located about 100 feet east of the marker for the Fort Dearborn site, at Michigan Avenue and Wacker Drive. All other construction is at least 250 feet away from markers, including proposed markers.

7.2.4 Cultural and Recreational Sites

No interference with any cultural sites is expected, because all proposed surface construction is at least 100 feet away from any existing or planned site. The closest construction would be at drop shaft number 55, located about 100 feet east of the bas-relief sculptures on the Michigan Avenue Bridge at Wacker Drive. All other construction would be at least 300 feet from any cultural site (listed in Section 3.2.4).

No existing recreational lands or lands scheduled for recreational development during the construction period would be affected by the proposed action. However, drop shaft Number 55, 56, 57, and 58 would be constructed in the prepared base for a planned river edge esplanade, part of the Illinois Center residential and business development on Wacker Drive between Michigan Avenue and Lake Shore Drive. TARP and its drop shafts are part of the Central Area Plan, or Chicago 21 Plan, which includes the Illinois Center. Therefore, the drop shafts are part of the planned esplanade. They only require consideration of the shaft surface structures in esplanade design, and scheduling development of the esplanade after construction of the drop shafts.

The more important existing recreational sites, such as the Equitable Plaza and Fountain, the boat landings at Michigan Avenue north shore and Marina Towers, and the river edge park between Clark and LaSalle Streets would not be affected by the proposed construction.

7.3 RESOURCES

The financial and labor resources which will be effected by the construction and operation of TARP, and, where applicable, the Mainstream Tunnel system, are discussed in this section.

7.3.1 Financial Resources

This section addresses the potential impact of allocating approximately $1.03 billion to the funding of the Tunnel Plan construction over the period 1976 to 1986. The alternative uses for these funds at the local, State, and Federal levels are considered. This section also addresses the significant potential for the loss of approximately $300 million of FWPCA funds to the State of Illinois which could be precipitated by failure to implement the Tunnel Plan. Table III-13 on page III-28 displays the allocation of total costs among the three levels; local, State, and Federal.

(1) Metropolitan Sanitary District of Greater Chicago (MSDGC)

If the District's share of the Phase I tunnel construction cost, $139.8 million, was not applied to the

TARP tunnel systems, the District could finance instream aeration to the waterway system receiving plant effluents from the Calumet, North-Side, and West-Southwest Treatment facilities and expand the treatment plants at these facilities.[1] These two components of the MSDGC's Flood and Pollution Control plan have an estimated constuction cost (in 1975 dollars) in excess of $1.1 billion. From a broader perspective, project alternatives can be addressed in context of the total budget of Chicago. Data supplied by the MSDGC indicate that the city's FY 1976 budget consists of appropriations totaling $1.15 billion. The major categories of appropriation include:

. Public safety	369 million
. Health	41 million
. Environmental	
– Water	102 million
– Sewer and waste disposal	97 million
. Transportation	221 million
. Housing and community improvement	39 million
. Human development, recreation, and culture	33 million
. Economic satisfaction and consumer protection	23 million.

In view of the multiplicity of the city's needs and the complexity of the budget formulation process, it is difficult to assess realistically the potential alternative uses of the $139.8 million (average of $14 million per year) of district funds targeted for the Phase I tunnel systems.[2] On a relative size basis, however, the average annual dollar volume is significant in comparison with several of the major budget appropriations. In terms of tax rate effect, however, the funding of the total Tunnel Plan will increase the construction portion of the MSDGC tax rate from \$.118/\$100 of assessed valuation to only approximately \$.171/\$100 in 1986.[1] This increase is relatively small in comparison to the overall city of Chicago rate (\$8.557/\$100 assessed valuation) and other tax rate figures such as:

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[1] These projects follow the tunnels in the District's priority scheme, as stated in the Facilities Planning Study MSDGC Overview Report.

[2] In terms of population, Chicago represents approximately two-thirds of the MSDGC. In terms of assessed valuation, Standard and Poor's Municipal Bond Selector, December 31, 1975, indicates that Chicago comprises approximately 61 percent of the District.

	Tax Per \$100 Assessed Value
Board of Education	\$3.47
City General Fund (fire, police, health, etc.)	\$2.929
Chicago Park District	\$ .774
Junior College Funding	\$ .268
County Government Services	\$ .65
Forest Preserve District	\$ .096

In summary, it does not appear that the MSDGC's portion of the Tunnel Plan funding would cause any significant reallocation of resources at the local level.

(2) State of Illinois

At the State level, the alternative use of the \$300 million currently targeted for the Tunnel Plan is the funding of the MSDGC aeration project and the expansion of the Calumet, North-Side, and West-Southwest Treatment facilities. These funds, however, would be obligated later than the FY 1976-77 time frame because the development of detailed plans for these facilities will not be completed until FY 1979 and, therefore, the proposed facilities will not be eligible for construction funding until FY 1979-80, according to recent estimates supplied by the MSDGC. The non-MSDGC alternative uses for the state funds include some 400 projects (approved by EPA for FWPCA funding) on the Illinois prioritized list of some 1,173 water pollution control projects. It must be emphasized, however, that traditionally half of the State of Illinois funds have been allocated to the MSDGC. The current portion of funds (available from the state) targeted for the District for the Tunnel Plan will not cause any significant or discernible disallocation of resources.

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[1] In FY1975, the MSDGC's tax rate was 40.05¢/\$100 of assessed valuation (25.23¢/\$100 for operations and maintenance; 11.75¢/\$100 for construction bonds). The 5.32¢/\$100 increase in the tax rate due to the Tunnel Plan was depicted in Table III-12.

(3) Federal

At the Federal level, the question of alternative uses of the FWPCA funds targeted for the Tunnel Plan is more complex and has very serious ramifications. If the Tunnel Plan is not implemented, there is a very high probability that approximately 90 percent of the current $323.6 million targeted for the MSDGC will be lost by the District and by the State of Illinois as well.

The potential loss to the MSDGC stems from the fact that the Calumet and North-Side Treatment facilities expansion project, while high enough in the priority list for FWPCA funds, will not meet the September 30, 1977 deadline for Step 3 funding eligibility. The Step 2 grants were obligated in May and June of 1975, and the construction design and specifications necessary for Step 3 funding are currently scheduled to be completed in January and July of 1979 respectively.[1] Step 3 funding for these two treatment facilities is estimated at $261 million.[2] Assuming these two projects did not qualify in time for existing FWPCA funds, it is estimated that only approximately 10 percent of the $323.6 million could alternatively be allocated to other MSDGC prioritized pollution control projects.

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[1] Construction design and specifications required for Step 3 funding for the West-Southwest Treatment Facilities are scheduled to be completed December 1979.

[2] These funds would be employed specifically to provide treatment capacity to provide for nutrient removal by nitrification and to provide plant capacity for tertiary level of treatment by filtration.

In terms of a statewide reallocation of the FWPCA funds, Illinois EPA has indicated a very low probability that any of the funds could be obligated to non-MSDGC projects before the September 30, 1977 deadline. According to recent estimates by the Illinois EPA, some 31 non-MSDGC projects are in jeopardy of not being ready by September 30, 1977 for Step 3 FWPCA funding. Failure to meet the September deadline would mean that the State of Illinois would lose the current $165 million of Federal funds allocated to these projects. These projects would thus require a comparable allocation of FY 1977 funds to initiate Step 3 funding.

According to Region V EPA, any funds not obligated within the appropriate deadline (September 30, 1977) would probably be reallocated by EPA headquarters among the other states according to the current allocation formula. These funds would thus be apportioned among projects (within these states) which are "next in line" in terms of state/EPA priority.

In terms of non-FWPCA alternatives for the funds, the question is as complex as the Federal budgeting process itself; at this time in the political process, however, it is possible that any unobligated funds would not be reassigned but rather indirectly passed back to the tax-payers via an extension, beyond June 30, 1976, of the current tax cuts and/or a further reduction in the tax liabilities of businesses and individuals.

7.3.2 Labor Resources

Effects on the labor force in the Chicago area due to construction of the Mainstream system should be slight. As shown in Section 7.1.3, the job generation in any one year will probably not exceed 850. Unemployment within the construction field in the Chicago metropolitan area for 1972 averaged a total of 5,910 out of an approximated labor supply of 114,000 persons. Unofficial estimates of the construction labor force in the Chicago metropolitan area for 1975 were 119,000 persons with an unemployment rate approaching ten percent yielding a labor pool of

11,900. Less than one percent of the construction labor force would be involved in the Mainstream project. Therefore, there should be no strain upon the labor force supply with respect to other construction projects.

7.4 TRANSPORTATION

Construction of the proposed project would generate additional truck and other vehicle traffic, causing short-term traffic disruption in some areas. Other transportation resources are not likely to be affected by project construction. Traffic impacts would occur near the construction and drop shaft sites and along the routes used by construction-related vehicles.

The traffic generated by construction activities primarily includes workers' commuting trips, as well as truck trips for rock and spoil disposal. The number of trips generated at the construction and drop shaft sites are discussed below.

7.4.1 Construction Shaft

An estimated 18 persons per shift would be required for tunnel excavation. Since there would be three shifts per day, assuming an occupancy rate of one person per car, the daily number of workers' trips to and from a shaft would be about 54. In addition, about three to five trucks per hour would be transporting rock and spoil material from the construction shaft to the disposal sites. Thus, the average number of daily trips generated at a construction shaft would range from 125 to 175. While workers' trip routes would vary, truck routes would be well-planned and constant. The most likely truck routes are shown in Figure VI-4 in Section 6.2.4. It is estimated that construction activities at a construction shaft site would last from 4 to 5.5 years, 312 days a year, and 24 hours a day.

7.4.2 Drop Shafts

Assuming ten persons per shift would be working at a drop shaft site for one shift per day, and assuming an occupancy rate of one person per car, the daily number of workers' trips to and from the shaft site would be ten.

No rock would be disposed of from drop shaft sites. However, an initial layer of soil would have to be excavated and disposed of. Depending on the drop shaft size, the estimated volume of excavated soil from one shaft would range from 4.5 to 315 cubic yards.[1] Assuming a truck capacity of 13 cubic yards, the total number of trips generated would range from 1 to 25 for the entire excavation of a drop shaft. The construction at a drop shaft site is expected to last for about three months, but the excavation would probably last only a few weeks. Assuming two weeks for the excavation, the daily number of truck trips would be less than three.

In addition to the above estimated trips, there would be truck trips for transporting construction equipment and material. These trips would generally occur at the beginning and the end of the construction period. The largest number of such trips would result from trucks transporting concrete for lining tunnels to construction shaft sites. This would add approximately one trip per hour to the above estimates.

Comparison of the total daily number of trips, as estimated above, with the normal traffic volume on affected roads given in Section 3.4, indicates that impact of the additional construction-related traffic on the traffic flow would be insignificant. During the peak construction year, in 1980, when all three tunnel systems would be under construction, the estimated total number of construction-related trips would be approximately 2,000 per day, including 650 truck trips. These trips would be scattered over many routes, however, and would have negligible impact on the existing traffic flow.

7.5 MAJOR PROJECTS AND PROGRAMS

The effects of the proposed surface and subsurface construction on other major projects and programs in the area would be negligible. However, certain potential exists for interference with the planned Core System subway, and this is explained in the following section, Transit Improvements.

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[1] Based on the smallest drop shaft diameter of two feet and the largest of 17 feet, and assuming 25 feet of soil cover, the loose excavated soil is conservatively assumed to occupy a 50 percent greater volume than its in-place volume.

Other projects discussed in this section are street improvement, truck and rail terminal improvements, acquisition of a public energy corridor, and public buildings.

7.5.1 Transit Improvements

While currently available maps showing the alignment of proposed subway improvements do not depict the final routes design, any potential interferences of the proposed Mainstream system with the routes are called out to draw attention to potential conflicts.

The planned Franklin Street subway alignments[1] pass through the proposed locations of drop shaft Numbers 48 and 50 in the area south of the Loop on the east side of the South Branch.[2] The Franklin Street subway also would pass very close to drop shaft Numbers 54 and 61 where the tunnel route crosses Wacker Drive and West Kinzie Street, respectively. The subway would also cross the proposed tunnel alignment at the Main Branch, but the vertical distance between the Mainstream Tunnel and the subway tunnel would be great enough to preclude any interference between the two projects.

A proposed Monroe Street subway alternative alignment[3] would pass very close to the proposed drop shaft Number 53 at Jefferson Avenue and Monroe Street.

Adjustments in the locations of the structures for the two projects can probably be made easily so that any interference between the two would be avoided. The proposed Mainstream system would not interfere with any existing subway tunnels or stations during its construction.

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[1] Chicago Urban Transportation District, "Transportation Engineering Program," Chicago Control Area Transit Project, October 1975.

[2] MSD Tunnel and Reservoir preliminary plans - photos plan maps from Aerial Photographs taken January 25, 1973, photo control from USGS 7½ foot quandrangle sheets, March 1974.

[3] Chicago Urban Transportation District, October 1975.

7.5.2 Streets and Expressway Improvements

All proposed shafts would be outside the proposed alignments of all road improvements. Several structures would be close, however, as listed below:

- Access shaft. Close to proposed Crosstown Expressway at Cicero Street and Sanitary and Ship Canal
- Drop shaft Numbers 33 and 34. Close to proposed improvements on Ashland Street near crossing of South Branch
- Drop shaft Number 57. Close to proposed Columbus Avenue extension and bridge across Main Branch.

No significant interference to these road improvements is expected from construction of the Mainstream Tunnel system.

7.5.3 Rail and Truck Terminal Improvements

The amount of land consumed during construction of the proposed system is too small to have any impact on plans for rail and truck terminal improvement, including plans for reallocating storage space and rerouting vehicular traffic.

7.5.4 Public Acquisition of Energy Utility Corridor

During shaft construction along the Sanitary and Ship Canal, construction contractors would be required under contracts with the MSDGC to survey all access routes to determine whether any pipeline crossings would need structural reinforcement prior to use. The contractors would also be required to make the necessary reinforcements. Therefore, no interference with pipeline operation is expected. Moreover, the amount of land consumed by the Mainstream shafts in the proposed energy corridor is minor compared to the area of the corridor, and the shaft locations would not preclude further utility development of the corridor.

7.5.5 Public Buildings

The proposed addition to the Lane Technical High School would be sufficiently remote from shaft construction so that no impact would be felt.

7.6 COMMITMENT OF RESOURCES

Construction of the proposed project would require about 450,000 cubic yards of concrete and undetermined quantities of other construction materials. Construction vehicles and equipment, as well as vehicles used by construction workers would consume approximately 186,000 gallons of gasoline and 100,000 gallons of diesel fuel during project construction.

Electrical power needed for constructing the TARP conveyance tunnels will be purchased rather than generated on site. All underground construction activities will rely heavily on electricity for power generation, whereas surface construction will use predominantly internal combustion engines. Tunneling machines or moles will be the principal consumers of electrical power, and they will account for much of the energy used in this project. The amount of power which may be consumed during construction is expected to be less than one percent of total energy consumed in the region. The demand that this would place on the metropolitan power grid depends on the number of tunnels being constructed at the same time, and the extent of other construction operations that are underway. Each tunnel is expected to consume a maximum of two to five megawatts of electrical power.

VIII. EFFECTS OF OPERATION ON THE NATURAL ENVIRONMENT

VIII. EFFECTS OF OPERATION ON THE NATURAL ENVIRONMENT

The significant effects of implementing TARP on the natural environment are presented in this chapter. The chapter is divided into three sections:

- Water Resources
- Land Resources
- Atmospheric Resources.

8.1 WATER RESOURCES

The operation of the proposed tunnel system will have a significant beneficial effect on the water resources of the Chicago area. Water quality conditions the past 20 years have been poor, and aquatic life has dwindled to only pollution-tolerant species. Implementation of the tunnel system will improve conditions so that aquatic life can begin to procreate and proliferate. This section describes the impact of tunnel operation on surface water and groundwater supplies of the affected area, as well as on wastewater and water management programs. The discussion addresses the following topics:

- Surface water quality and use as a resource
- Groundwater quality
- Impact on wastewater
- Interaction with other water management programs.

8.1.1 Surface Water

The deep tunnel system proposed by the MSDGC will affect surface water resources of the Chicago area in a variety of ways. Discussion of the impacts will follow the structure of Chapter II; the description of the existing natural environment.

(1) Water Quality

Completion of the three deep tunnel systems will reduce spills to area waterways, caused by combined-sewer overflows, from approximately 100 occasions per year to about 10 occasions per year. The tunnel systems will capture for treatment approximately 51 percent of the annual volume of overflow from combined sewers, thus reducing discharges to area waterways from the present level of 113,500 acre-feet per year to a level of 55,800 acre-feet per year. Because the tunnel systems will capture the most heavily polluted portion of the overflows, the percent reduction in the pollutant load in general will exceed the percent reduction in overflow volume. After treatment, the amount of biological oxygen demand (BOD) released to the waterways is expected to be reduced by about 78 percent (net) from present releases (approximately 38,700,000 lbs/yr to roughly 8,500,000 lbs/yr). Discharges of suspended solids will drop from a current level of about 180,500,000 lbs/yr to roughly 45,125,000 lbs/yr (a net reduction of about 75 percent). Currently, overflows from the combined sewers occur 17.4 percent of the time, releasing, untreated, the equivalent of 8.7 percent of the yearly average dry weather flow to area waterways.[1] Implementation of the tunnel system alone will limit overflow episodes to approximately 1.5 percent of the time, reducing releases of untreated sewage to less than 2 percent of the yearly average dry weather flows. The statistics on pollutant reduction cited above and their sources are summarized in Table VIII-1.

By reducing the number of yearly combined-sewer overflows from 100 to 10, a significant result will be that the average duration of nonoverflow periods will be increased from the current 3.1 days to 24 days. This means that the quality of the waterways will be governed, in general, by dry weather flow conditions. Dry weather flow conditions, in turn, are strongly influenced by effluent discharges from area treatment plants and by BOD released through the accumulated benthal deposits.

As described in Section 2.1.1, the hot summer months are the time of greatest strain on area water quality. During this period, decomposition of organic material in the deposits, retarded during the cooler months, is accelerated. Decomposition results in consumption of dissolved oxygen (DO) and creation of anaerobic conditions in the deposited material. Presently, under dry weather flow conditions (late summer months), water quality along major sections of the area's three primary waterways fails to meet minimum Illinois standards for restricted waters. This situation was documented in the Chapter II discussion of existing water quality in terms of simulated DO concentrations along the length of the major waterways. That discussion is continued and updated here.

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[1] Hearing on the Proposed Chicago Tunnel and Reservoir Plan, Chicago, Illinois, March 28, 1974.

Table VIII-1
Pollutant Discharges to Area Waterways
Before and After Operation of Phase I Tunnel System

Parameter	Existing Conditions	After Phase I	Percent Reduction
Volume of Sewer Overflow Released	113,500 acre-feet[1]	55,800 acre-feet[1]	51
BOD	38,700,000 lbs/yr[2]	8,500,000 lbs/yr[1]	78[3]
Suspended Solids	180,500,000 lbs/yr[1]	45,125,000 lbs/yr[1]	75
Untreated Sewage	8.7% of annual dry weather flow[2]	1.75% of annual dry weather flow[1]	80

[1] Value calculated from information by the MSDGC in private communication, February 10, 1976.

[2] Hearing on the Proposed Chicago Tunnel and Reservoir Plan, Chicago, Illinois, March 28, 1974.

[3] Net reduction after treatment.

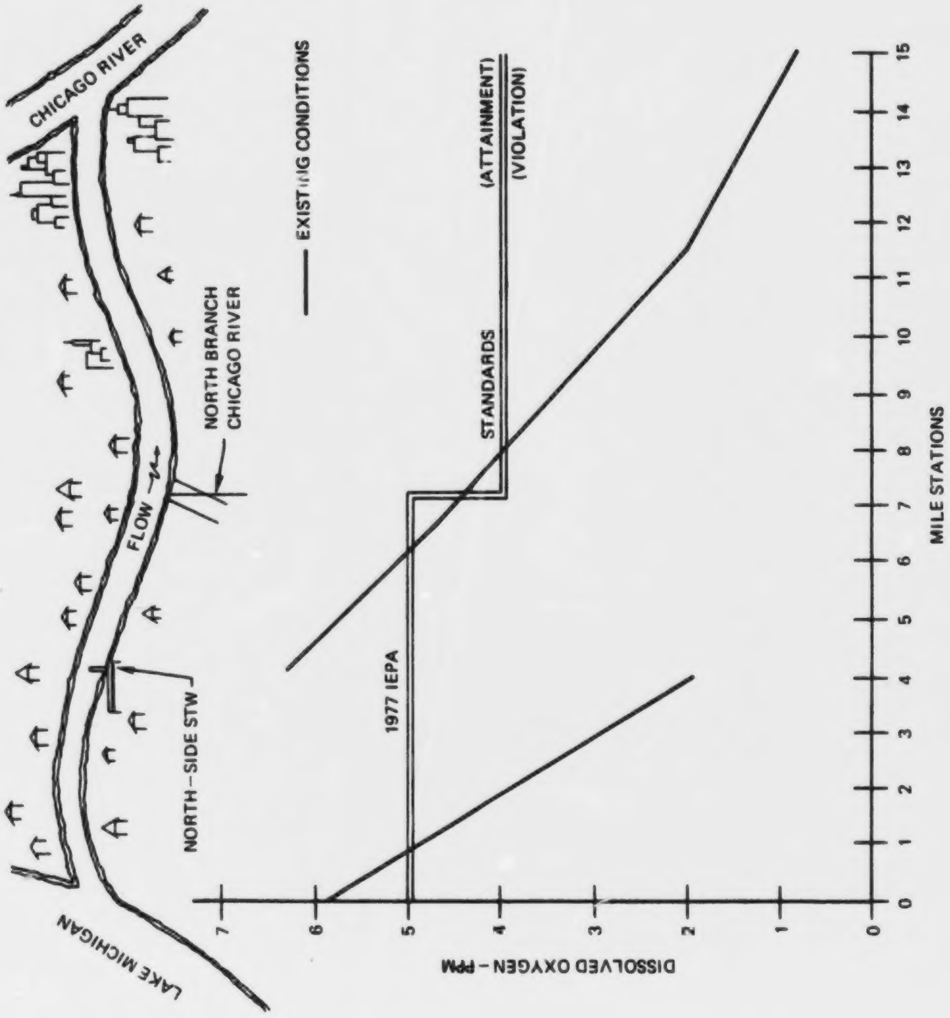
Chapter II discussion of existing water quality in terms of simulated DO concentrations along the length of the major waterways. That discussion is continued and updated here.

The upgrading of DO concentrations along area waterways as a result of tunnel operation is shown graphically in Figures VIII-1,2, and 3. These figures compare DO concentrations under existing dry weather flow conditions with concentrations expected with the Mainstream and Calumet Phase I tunnels on line. The Des Plaines River system has not yet been modeled on the computer because of insufficient data. This system, however, will be modeled in the Section 208 planning program. For these simulations, average 1974 treatment plant effluents were used, along with flows from Lake Michigan representing average lockages (Lake Michigan water used in lock operations) and leakages (lake water leaking through lock gates). The simulations of conditions with tunnels on line assume increased discharges from the West-Southwest and Calumet treatment plants to reflect the expected dewatering of the tunnel system in post-storm periods. In addition, the benthic oxygen demand (part of the total BOD) for the simulation of Phase I conditions was assumed to be reduced by 80 percent of that used for modeling existing conditions (see Part (5) below.) The assumptions used in the simulations are summarized in Table VIII-2.

In general, the simulations show that with the Phase I tunnels on line, an improvement in DO concentrations averaging about 1.7 mg/l above existing conditions can be expected over the approximately 80 miles of waterways modeled. However, as is evident from the figures, the 4 mg/l dissolved oxygen standards will not be met over 70 percent or about 60 miles, of the waterway during dry weather flow conditions (mostly during late summer months). This is in addition to those ten occasions during the year on which most standards will not be met because the combined-sewer overflows will exceed tunnel storage capacity, causing overflow to the waterways.

In addition, it is expected that Illinois restricted use standards will not be met under dry weather flow conditions without additional measures because of the quality of effluent from area treatment plants. Although detailed information is lacking, it appears that restricted use standards for phosphorus and ammonia are not likely to be met without upgrading of treatment facilities. Even though the tunnel system would intercept

FIGURE VIII-1
Simulation of Dissolved Oxygen
Concentrations Along North
Shore Channel and North
Branch of the
Chicago River[1]



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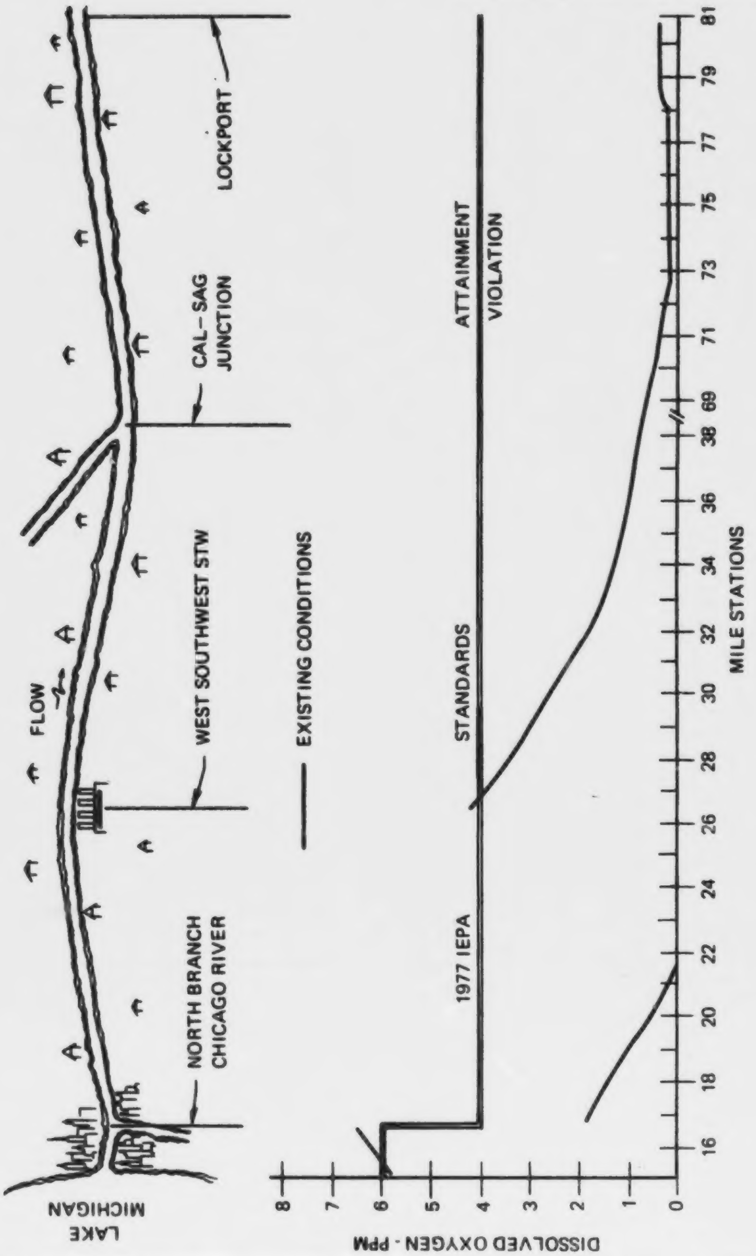
[1] Kieffer and Associates, Memorandum to MSDGC, February 3, 1976.

FIGURE VIII-2
Simulation of Dissolved Oxygen Concentrations Along the Main Channel From Lake Michigan to Lockport[1]



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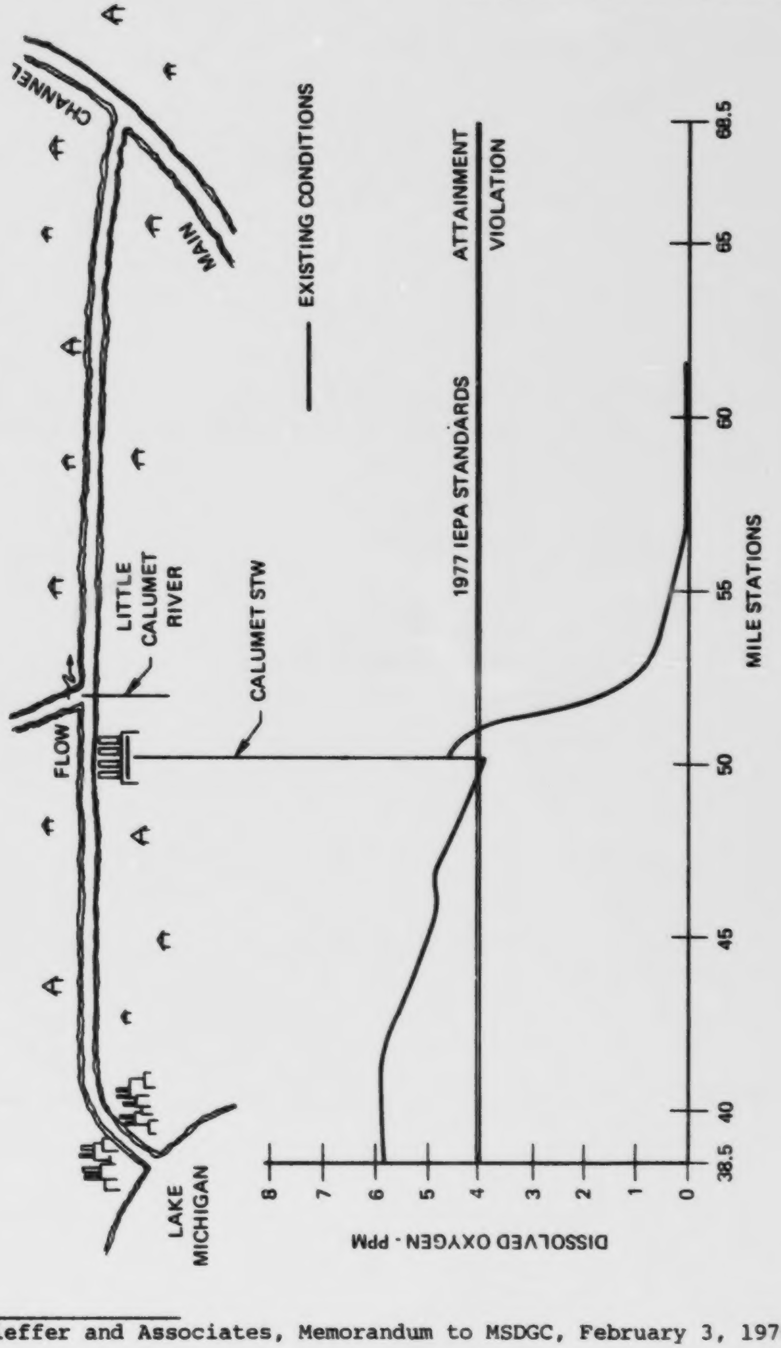
[1] Kieffer and Associates, Memorandum to MSDGC, February 3, 1976.

FIGURE VIII-3
Simulation of Dissolved Oxygen Concentrations Along the Calumet River System[1]



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[1] Kieffer and Associates, Memorandum to MSDGC, February 3, 1976.

Table VIII-2
Simulation Model Inputs[1]

Dry Weather, Existing Conditions

	North-Side Plant	West-South-West Plant	Calumet Plant	Lake Michigan
Flow (cfs)	505	1274	332	278
BOD (mg/l)	10	8	20	0
DO (mg/l)	7.0	7.0	7.0	6.0

Benthic Demands - Same as previously used by the MSDGC as a result of calibration of computer with measured instream DO.

Dry Weather, First Phase TARP

	North-Side Plant	West-South-West Plant	Calumet Plant	Lake Michigan
Flow (cfs)	505	1460	366	278
BOD (mg/l)	10	8	20	0
DO (mg/l)	7.0	7.0	7.0	6.0

Benthic Demands - Twenty percent of those used for existing conditions.

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[1] Westfall, D.E., Kieffer and Associates, Memorandum to the MSDGC, February 3, 1976.

and capture a significant portion of the 1,350 tons per year of phosphorus currently discharged to combined-sewer overflows by treatment plants, only about 20 percent[1] will be removed at the plant with current levels of treatment. The remaining 80 percent of the phosphorus will be released to the waterways until additional treatment is provided.

Likewise, until the MSDGC's large plants are upgraded to provide tertiary-level treatment, restricted use standards for ammonia are not likely to be met even with the implementation of the tunnel system. Currently, the North-Side, West-Southwest, and Calumet treatment plants will not be able to meet Illinois EPA standards, which go into effect by December 31, 1977. Ammonia in the effluent from the Calumet plan in particular is likely to cause violations of the Illinois Standards for Secondary Contact and Indigenous Aquatic Life along the Calumet River system. Effluent concentrations of ammonia from area treatment plants are shown in Table II-7, page II-37.

In summary, implementation of Phase I tunnels will limit combined-sewer overflows to about 10 occasions per year. Dry weather flow conditions will then be the influencing factor in water quality in the area. Under such conditions, Illinois Standards for Secondary Contact and Indigenous Aquatic Life will not be met for DO and probably not for phosphorus[2] and ammonia. For these reasons, implementation of the Phase I tunnels will not enable an upgrading in water uses along large reaches of the major Chicago area waterways. Rather it is clear that other programs for pollution control must also be undertaken to attain state standards on these river systems. Other programs being considered toward this end are: upgrading of existing treatment plants, use of instream aeration, and implementation of TARP Phase II. The water quality implications of these programs are discussed briefly below.

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[1] MSDGC Testimony, Hearing on the Proposed Chicago Tunnel and Reservoir Plan, Chicago, Illinois, March 28, 1974.

[2] Limits established in effluent discharge standards apply for all waterways.

The increment of oxygenation provided by an in-stream aeration system in addition to the increment provided by the tunnel and reservoir system and the upgrading of MSDGC treatment plants would allow Illinois Secondary Contact and Indigenous Life standards to be met over the entire 80-mile length of the modeled rivers. The computer simulations of DO shown in Figures VIII-4, 5, and 6 assume 11 aeration stations over the modeled lengths of the Main Channel and Calumet River systems. The DO characteristics of the Des Plaines River system has not as yet been simulated by computer models.

Upgrading of area treatment plants in conjunction with operation of the tunnels and reservoirs could have a significant beneficial effect on water quality during dry weather flow conditions. Upgrading to tertiary treatment with nitrogen and phosphorus removal would enable attainment of Illinois standards for ammonia and phosphorus in area waterways. In addition, DO concentrations would increase due to the absence of ammonia, although the improvement would still not be enough to meet DO standards along approximately 24 of the 80 miles, or 30 percent of the modeled waterways. Results of MSDGC computerized simulations of the impact of this combination on DO concentrations are portrayed in Figures VIII-4, 5, and 6.

The addition of storage reservoirs to the tunnel system would virtually eliminate release of combined-sewer overflows to surface waterways. With the tunnels and reservoirs on line, the MSDGC expects overflow events to be limited to three or fewer occasions over a 27-year period.[1] This would prevent violation of Illinois standards under wet weather flow conditions. State standards will still not be met, however, under the critical summer dry weather flow conditions, because of high ammonia and phosphorus concentrations in the effluent discharged from treatment plants, and because of the depletion of DO concentrations in the waterways. Implementation of the tunnels and reservoirs will still not enable attainment of the 1977 DO standard over roughly 40 of the 80 miles of waterways. The impact of the combination of the tunnels and reservoirs on DO concentrations is shown in Figures VIII-4, 5, and 6.

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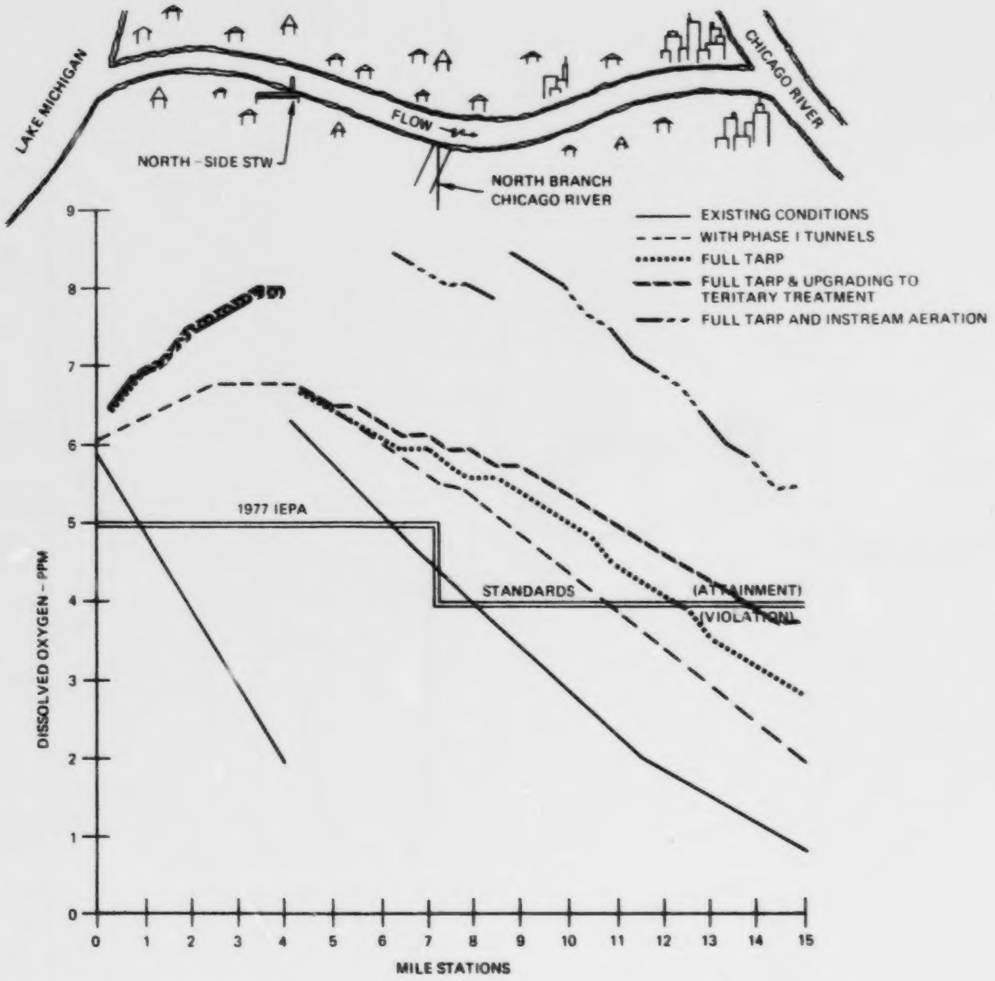
[1] MSDGC, "Facilities Planning Study - MSDGC Overview Report," Revised January 1975.

FIGURE VIII-4
Simulation of Dissolved
Oxygen Concentrations Under
Combination of Tunnels and
Reservoirs[1]

North Shore Channel
And
North Branch Chicago River



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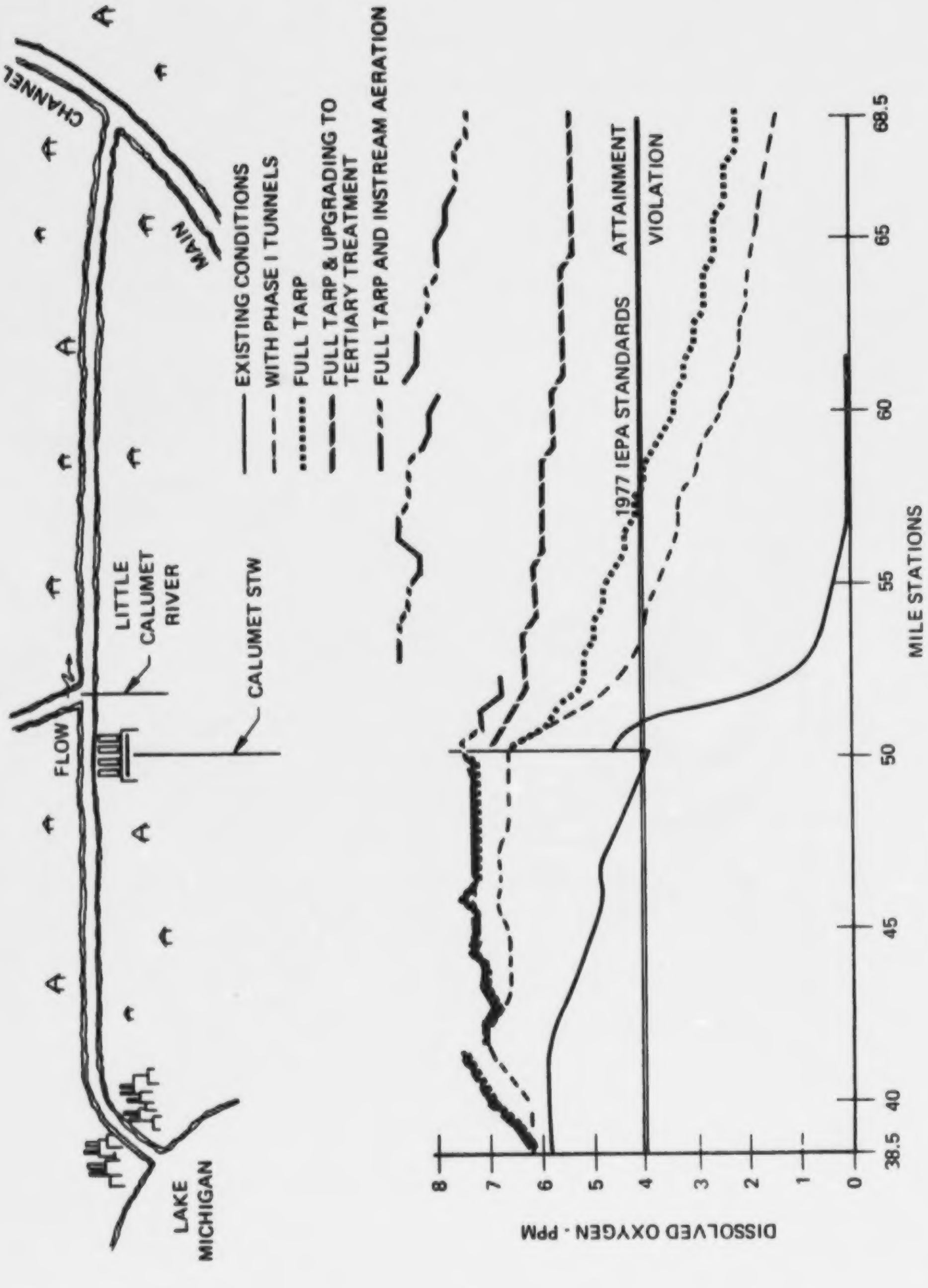
[1] J. Irons, MSDGC, Personal Communication, February 10, 1976.

FIGURE VIII-5
Simulation of Dissolved Oxygen Concentrations Under Combination of Tunnels and Reservoirs[1]

Calumet River and Cal-Sag Channel



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[1] J. Irons, MSDGC, Personal Communication, February 10, 1976.

Main Channel - Lake to Cal-Sag

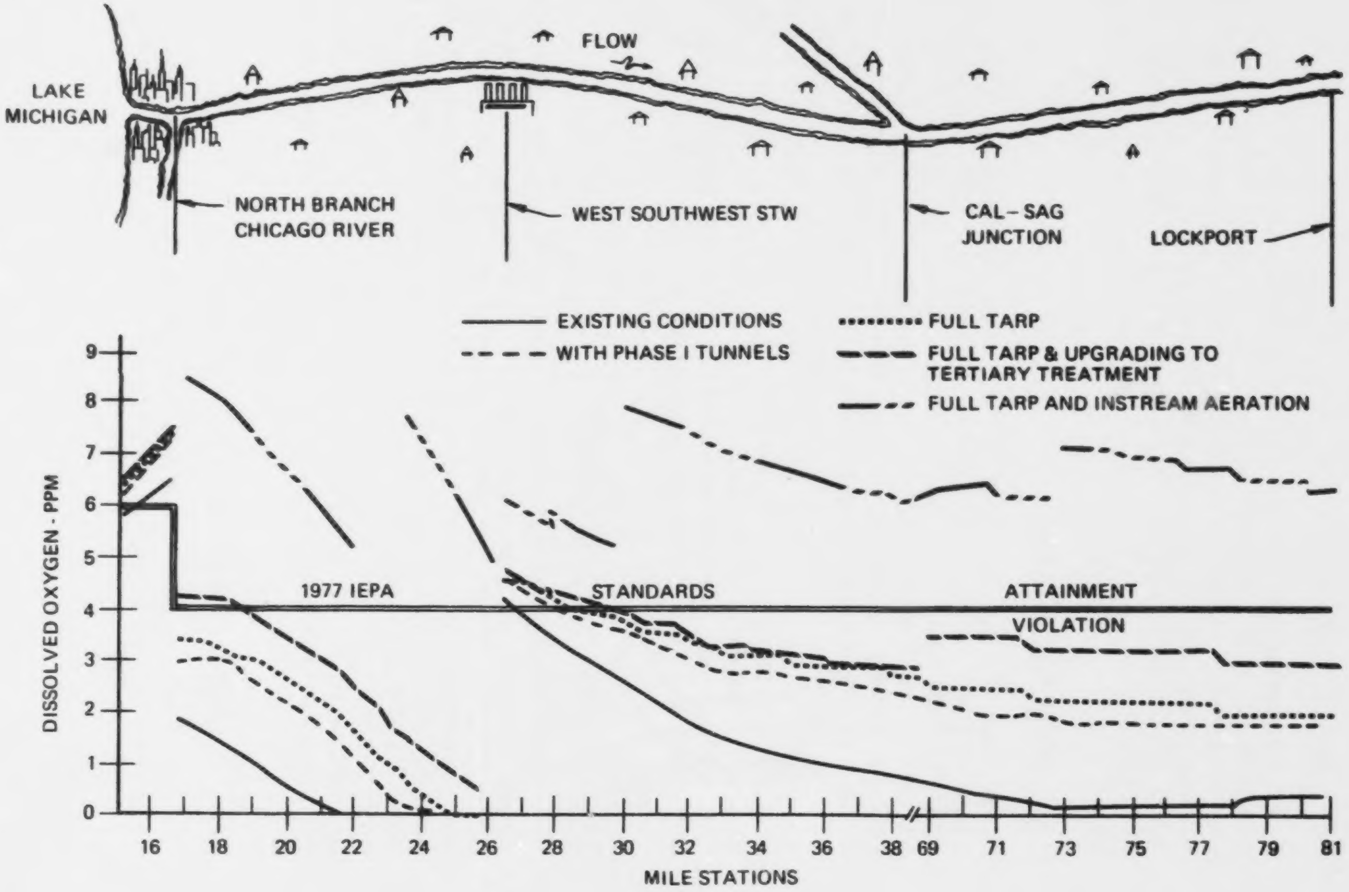

FIGURE VIII-6
Simulation of Dissolved Oxygen Concentrations Under Combination of Tunnels and Reservoirs[1]

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[1] J. Irons, MSDGC, Personal Communication, February 10, 1976.

Information relating to the impact on water quality of the various pollution control options described above is summarized in Table VIII-3.

(2) Water Quantity

Implementation of Phase I of TARP is not expected to have a significant impact on annual flow rates and water levels along the major river systems. The tunnels themselves are too limited in capacity to reduce noticeably the flood stages attained during the largest area storms.

(3) Flow Regulation

Capture of 51 percent of the combined-sewer overflow volume with subsequent treatment and release to area waterways will have some impact on flow regulation. As noted in Table VIII-2, operation of the tunnel system is expected to increase the average flow of water from the West-Southwest and Calumet plants by about 13 percent and 9 percent, respectively. This modest increase will allow a smoothing out of flow rates in the Mainstream and Calumet River systems except for those occasions when large storms occur. In short, the effect of tunnel operation on flow regulation throughout the Chicago area is expected to be minor.

(4) Domestic Water Supply

The capture, treatment, and release of combined-sewer overflows is expected to have little, if any, impact upon domestic water supplies. Plant effluent may eventually be upgraded to the point where it can substitute for a portion of that direct diversion from Lake Michigan used for maintenance of water quality. Until then, it is unlikely that the additional flows provided by TARP Phase I will enable the reallocation of high quality Lake Michigan water for domestic uses.

(5) Benthal Deposits

Implementation of the tunnel system will reduce releases of suspended solids to the waterways by about

TABLE VIII-3
Summary of Pollutant Concentration Ranges in Chicago's Surface Water Systems

Pollutant	Chicago River — Sanitary and Ship Canal System	Calumet River System	Des Plaines River System	Applicable Illinois Standard
Dissolved oxygen (DO)	1.2 to 7.7 mg/1	3.9 to 9.0 mg/1	6.0 to 10 mg/1	4.0 mg/1 (1977)^1 5.0 mg/1 min.^{2}
Biochemical oxygen demand (BOD)	5.2 to 9.2 mg/1	4.1 to 7.3 mg/1	5.0 to 6.7 mg/1	10 mg/1^3
Ammonia (as N)	0.8 to 6.2 mg/1	1.3 to 13 mg/1	0.3 to 1.2 mg/1	4.0 mg/1^1 1.5 mg/1^2
Suspended solids (SS)	19 to 54 mg/1	12 to 73 mg/1	29 to 68 mg/1	12 mg/1^3
Fecal coliform	477 to 12,700 (counts/100 ml)	152 to 738 (counts/100 ml)	411 to 8,700 (counts/100 ml)	1000/100 ml^1 200/100 ml^2

1 Secondary Contact and Indigenous Aquatic Life Standards applicable to Chicago River-Sanitary and Ship Canal system and Calumet River system.

2 General Use Standard applicable to Des Plaines River systems.

3 Effluent Discharge Standard.

75 percent.[1] It is expected that only a thin layer of sludge will be deposited on the river bottom after an overflow event once the tunnels have been placed in operation. Because of this, the number of instances in which anaerobic decomposition occurs should be reduced significantly.

A significant reduction in benthic oxygen demand is predicted as a result of Phase I TARP. The tunnel will capture all but the largest overflows, expanding the average duration of nonoverflow conditions from 3.1 to 24 days. Because of this, benthic oxygen demand will be reduced to about 20 percent of current levels.[2] Dredging of existing sludge deposits from the waterways should further reduce the oxygen demand from organic sediment.

8.1.2 Groundwater

The operation of the tunnel system and associated subsystems is expected to have two types of effects on the natural environment. Wastewaters conveyed by the system may have an impact on groundwater resources caused by exfiltration. Conversely, these resources may have an impact on the tunnels because of groundwater infiltration.

Although concrete linings and rock grouting will be used to control infiltration and exfiltration (see Section 5.1.2 of Chapter V), no combination of lining and grouting can completely eliminate the inflow and outflow of water between the tunnel and the surrounding rock. Should the grouting program fail, infiltration or exfiltration will most likely occur and will cause a significant impact on tunnel operations. The inflow or outflow rates are expected to be at the tunnel maximum level, as indicated in Section 6.1.2 and illustrated in Figures VI-1, VI-2, and VI-3. The extent of grouting failures, however, can be monitored by routine tunnel inspection and/or by water level fluctuations in observations wells.

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[1] Westfall, D.E., Kieffer and Associates, Memorandum to MSDGC, February 3, 1976.

[2] Ibid.

Assuming that the number of grouting failures are kept to a minimum, the impacts of groundwater infiltration and wastewater exfiltration during operation of the tunnel system are not expected to be significant. The effects of these impacts which are unique to infiltration and exfiltration, are discussed in the following sections.

(1) Infiltration

During dry weather conditions, the pressure inside the tunnel will generally be low because of the nearly dry tunnel conditions. During normal storm events, the tunnels will be partially full, and the pressure will still be lower than the groundwater inflow pressure. Therefore, when the tunnels are either dry or partially full, groundwater infiltration will take place. If the tunnel is grouted according to specifications, inflow is not expected to exceed 0.05 MGD/mile. For the Mainstream Tunnel, groundwater infiltration may be as low as 0.03 MGD/mile. Although the inflow rate to the tunnel is small, the pressure will still be high enough to prevent exfiltration of wastewater from the tunnel into the aquifer.

As revealed in Chapter V, the grouting program is designed to limit overall infiltration to 0.05 MGD/mile or less. To achieve a rate lower than this, chemical and epoxy grouts may be required in addition to cement grouts. This requirement is dependent on nature and density of fracturing and on seepage or inflow conditions encountered during construction which dictate what grouting method should be employed.

Without the tunnel grouting and/or lining programs, maximum infiltration of groundwater can occur at the rates specified in Section 6.1.2. The impact, therefore, is expected to be significant with respect to tunnel operations and their associated systems. The flow rate can be as high as 50 MGD total for the Mainstream Tunnel system and represents over 15 percent of the system's treatment capacity.

Based on the results of tests conducted in the tunnels completed to date, the grouting program will effectively control groundwater infiltration. The degree of effectiveness, however, can only be determined by additional field tests during operation. The program appears to be sufficiently flexible to accommodate the range of conditions which may be encountered during both construction and operation of the tunnel systems.

(2) Exfiltration

During major storm events, the hydraulic pressure in the tunnel may exceed the inward pressure of the aquifer. Exfiltration will then occur until tunnel pressure and aquifer pressure achieve equilibrium. This would result in adverse effects on groundwater quality in the vicinity of the tunnel, and would necessitate an aquifer protection system. Preservation of the aquifer can be achieved by establishing or preserving two physical conditions throughout the project area:

- Maintenance of a high piezometric level within the aquifer in relation to hydraulic grade levels in tunnels and shafts by a system of recharge wells
- Limitation of exfiltration as well as infiltration by a combination of grouting and tunnel lining, as discussed previously.

Although data was not available to indicate the expected maximum tunnel pressure during a simulated flood condition, studies have identified general areas in which aquifer recharge will be necessary to sustain potentiometric levels and thus to avoid exfiltration.[1] Figure VIII-7 shows areas which may require installation of recharge wells. These areas correspond to existing or imminent low potentiometric surface areas. The need for future recharge wells was based on projected water level declines. The recharge system, if required, would consist of wells spaced approximately

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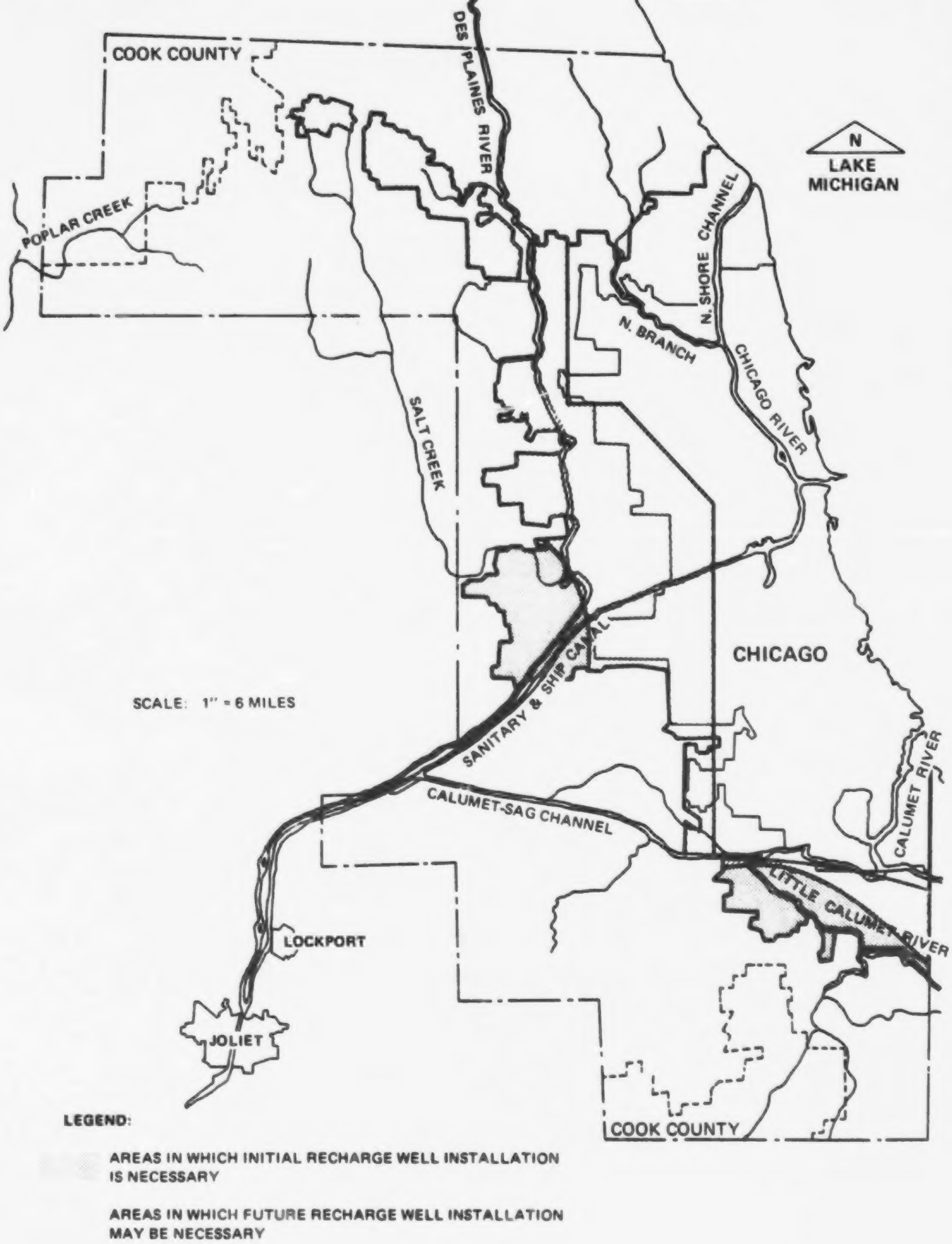
[1] Harza Engineering Company, "Development of a Flood and Pollution Control Plan for the Chicagoland Area: Geology and Water Supply," Technical Report, Part 4, MSDGC, 1972.

FIGURE VIII-7
Aquifer Protection
Needs[1]


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
POPLAR CREEK
N. SHORE CHANNEL
N. BRANCH
CHICAGO RIVER
SALT CREEK
CHICAGO
SANITARY & SHIP CANAL
SCALE: 1" = 6 MILES
CALUMET RIVER
CALUMET-SAG CHANNEL
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
COOK COUNTY
LEGEND:
▨ AREAS IN WHICH INITIAL RECHARGE WELL INSTALLATION IS NECESSARY
☐ AREAS IN WHICH FUTURE RECHARGE WELL INSTALLATION MAY BE NECESSARY

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[1] HEC, 1972

1,000 feet apart.[1] The system is designed to allow a water injection rate of 100 gpm which would result in an equivalent recharge amount of 0.73 MGD per mile of tunnel. Due to the variability of the aquifer, additional testing will be necessary during construction to delineate specific locations for recharge wells and to determine appropriate injection rates.

According to present plans, the proposed tunnel system will be situated beneath existing potable water main systems at a minimum vertical distance of 70 feet. In order to determine the potential for pollution of the potable water from exfiltration of the combined sewage, a "worst case" analysis was performed.[2] This analysis was based on the following assumptions:

- The sewage tunnel is unlined, and only major open joints have been grouted
- Pressure head in the sewage tunnel is the same as at land surface
- Ratio of horizontal to vertical permeabilities is one K_hK_v-1, and permeability rate is 0.001 ft/min
- The water main is empty
- The concrete lining of the water main is damaged to the extent that it does not function as a seepage boundary.

The analysis indicated that even under such critical and unlikely circumstances, it would take approximately 280 days for the exfiltrated seepage to reach the water main, and the rate of inflow in the main would be about 0.07 gpm per foot of tunnel effected (or 0.5 MGD/mile).

It is extremely unlikely that this situation will occur. Based on the projected rate of flow of the sewage effluent, there would be sufficient time to implement mitigative measures in the event exfiltration occurs, providing observation wells are installed.

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[1] HEC, 1972.

[2] Ibid.

A "worst case" situation would necessitate the emptying of the water main for repairs to damaged lining. Monitoring efforts (i.e., water level and water quality movements) in nearby observation wells will reveal any adverse or potentially adverse changes before they could become manifest in non-test wells located farther away. These observation wells should be located along the entire length of the tunnel route. Figure VIII-8 shows the locations of existing observation wells as revealed in a 1975 report by HEC.

In view of the heterogeneous nature of the aquifer system, the observations and conclusions presented herein should be considered as estimates or relative assessments. The distribution of observation wells along the Mainstream Tunnel system appears adequately dense for effective monitoring. The potentiometric surfaces and tunnel pressures of this system, however, will have to be more fully defined to adequately calculate exfiltration potential and to design the proper exfiltration control systems.

8.1.3 Wastewater

Treatment of captured overflows from the combined sewers is the ultimate goal of the proposed deep tunnel system. The dewatering of intercepted flows from the tunnels is designed to be completed within about 2.5 days to avoid the possibility of septicity in the tunnels. Implementation of the tunnel system will increase dry weather flows from the West-Southwest and Calumet plants by roughly 13 percent and 9 percent, respectively.[1] Increased flows through these two plants and changes in selected effluent characteristics relative to 1973 levels are shown in Table VIII-4.

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[1] Westfall, D.E., Kieffer and Associates, Memorandum to MSDGC, February 3, 1976.

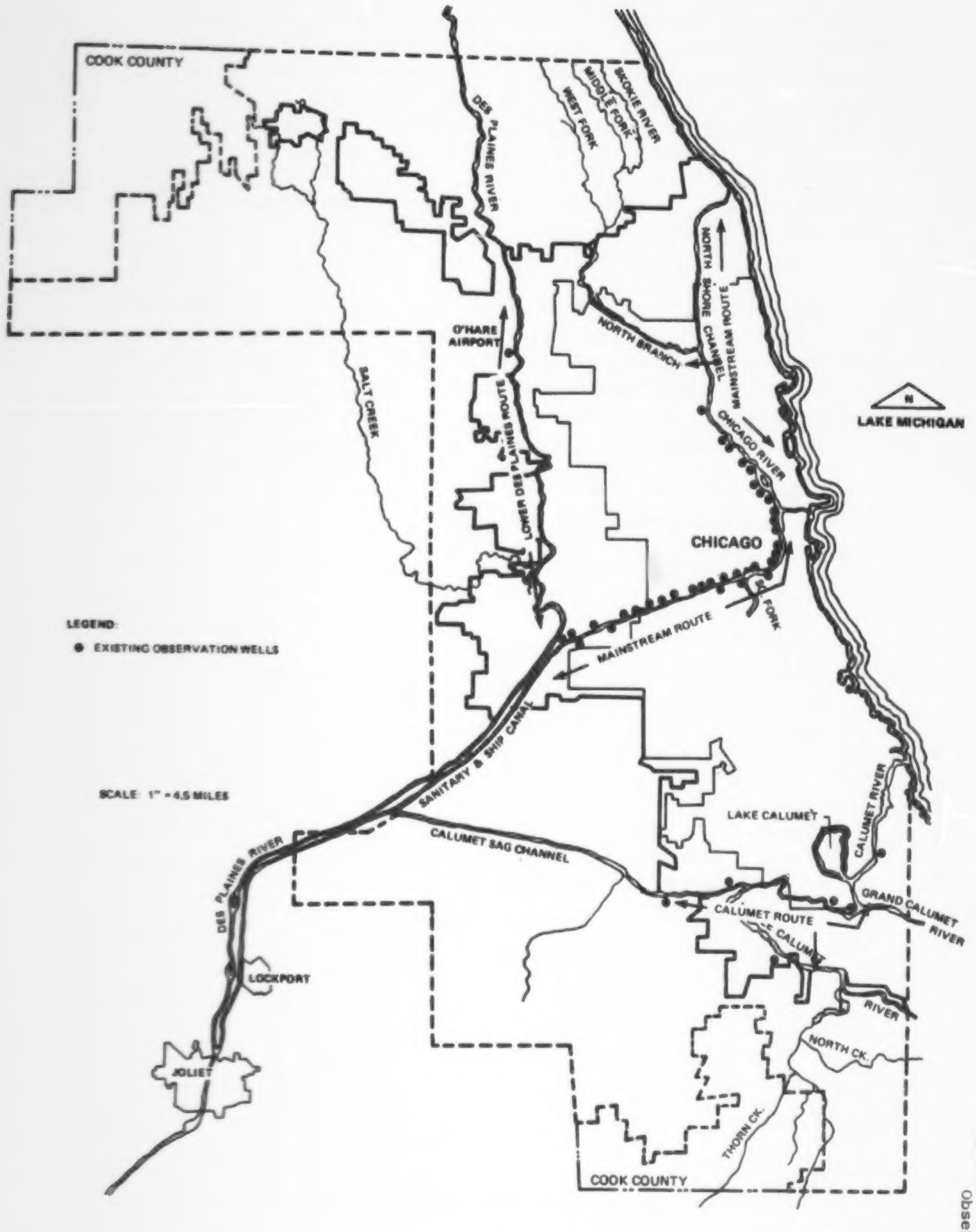
COOK COUNTY
DES PLAINES RIVER
WEST FORK
MIDDLE FORK
SKOKIE RIVER
NORTH SHORE CHANNEL
MAINSTREAM ROUTE
NORTH BRANCH
O'HARE AIRPORT
SALT CREEK
LOWER DES PLAINES ROUTE
CHICAGO RIVER
LAKE MICHIGAN
N
CHICAGO
FORK
LEGEND:
● EXISTING OBSERVATION WELLS
MAINSTREAM ROUTE
SANITARY & SHIP CANAL
SCALE: 1" = 4.5 MILES
LAKE CALUMET
CALUMET RIVER
CALUMET SAG CHANNEL
GRAND CALUMET RIVER
DES PLAINES RIVER
CALUMET ROUTE
CALUMET
RIVER
LOCKPORT
NORTH CK.
JOLIET
THORN CK.
COOK COUNTY

FIGURE VIII-8
General Location of Existing
Observation Wells

Table VIII-4
Comparison of Anticipated Effluent Flows and Characteristics Resulting from Phase I Tunnel Dewatering with 1973 Average Operating Parameters[1]

	North-Side STP		West-Southwest STP		Calumet STP	
	Phase I	(1973)	Phase I	(1973)	Phase I	(1973)
Flow (cfs)	505	(505)	1460	(1340)	366	(325)
DO (mg/l)	7	(7)	7	(7)	7	(7)
BOD (mg/l)	10	(10)	8	(7)	20	(15)
NH_3 (mg/l)	5	(5)	7	(7)	18	(18)

[1] Westfall, D.E., Keiffer and Associates, Memorandum to MSDGC, February 3, 1976.

As is evident from the table, the effect of Phase I tunnel dewatering operations on treatment plant effluent quality is not expected to be significant. The likely dilution of intercepted flows and the modest increases in flow to the treatment plants from dewatering form the basis for this finding.

Effluent flows and chemical characteristics are indicated in Table VIII-5, assuming addition of the storage reservoirs and upgrading and expansion of the MSDGC's large plants to provide tertiary treatment.

Table VIII-5
Effluent Flows and Chemical Characteristics Resulting From Addition of Reservoirs and Upgrading of MSDGC Plants[1]

	North-Side STP		West-Southwest STP		Calumet STP	
	TARP	(Upgrading)	TARP	(Upgrading)	TARP	(Upgrading)
Flow (cfs)	505	(505)	1587	(1587)	391	(391)
DO (mg/l)	7	(7)	7	(7)	7	(7)
BOD (mg/l)	10	(8)	8	(8)	20	(8)
NH_3 (mg/l)	5	(2.5)	7	(2.5)	18	(2.5)

[1] Irons, J., MSDGC, personal communication, February 10, 1976.

Ammonia concentrations of 2.5 mg/l for the upgraded plants represent the minimum level that must be attained by December 31, 1977 to meet Illinois Effluent Discharge standards. In addition, under these standards, BOD levels from MSDGC plants must be limited to no more than 10 mg/l by December 31, 1977. The projected improvement in BOD levels beyond the mandated limit due to plant upgrading is a result of MSDGC's comparison effort to meet DO standards in the waterways by limiting BOD releases from MSDGC treatment plants. Currently, Illinois has no BOD standards for waterways.

At this time, insufficient information on the design and operation of the reservoir storage systems is available to enable a determination of the effect of variable dewatering rates on the quality of treatment plant effluent.

8.1.4 Water Management Programs

Improvements in water quality resulting from operation of the tunnel system are, in general, consistent with the aims of other area water management programs. The tunnel system, in conjunction with a water storage system, is widely recognized in virtually all area plans as a necessary component to control pollution and flooding problems in the Chicago area. Although the tunnels alone would not attain fully the goals of the various programs identified in Section 2.1.4, operation of the tunnels without the reservoirs would enable pollution control aims to be at least partially accomplished.

A decision to construct the tunnel system prior to the completion of the 208 Planning Program would certainly reduce the options open to the 208 planning agency (Northern Illinois Planning Commission) in developing an areawide waste treatment management plan. With the commitment to a significant component of the TARP system, the potential utility and impact of the waterway monitoring and modeling to be undertaken as part of the 208 program will necessarily be reduced. However, the 208 Planning Program is still expected to provide significant data affecting the design and implementation of other components of the TARP project, including reservoir storage of combined sewer overflows, upgrading and expansion of area treatment plants, and the use of instream aeration.

No major conflicts could be identified between implementation of the tunnel system and other water management programs in the Chicago area.

8.2 LAND RESOURCES

The effects on land resources of implementing TARP are discussed in this section of the EIS. The assessment focuses mainly on the Mainstream Tunnel system and is presented under the following land resource categories:

- Flood-Prone Areas
- Geology and Seismicity
- Land Disposal of Sludge.

8.2.1 Flood-Prone Areas

The flood-prone areas within the MSDGC combined-sewer service area are expected to be beneficially affected as a result of Mainstream Tunnel system operation. The effect will be very small, however, since the storage capacity of the Mainstream Tunnel is only 3,180 ac-ft, which is equivalent to approximately 0.7 inches of runoff water. The drainage basins and areas susceptible to overbank flooding associated with the Mainstream Tunnel route have been described in Section 2.2, Land Resources, of this EIS. Although some flooding as well as overflow relief can be expected within certain portions of these drainage basins and flood-prone areas, the amount will be insignificant unless a larger storage system is incorporated as part of the tunnel system. For the 59th-to-Addison segment of the

Mainstream system, there will be 177 overflow relief points and 82 drop shafts[1,2] for collecting runoff wastewaters. Most of these relief points and drop shafts will be located within flood-prone areas. Table VIII-6 presents the number of drop shafts and relief points for the 59th-to-Addison segment as compared to all the TARP systems. This table provides an overview of the incremental, beneficial effects which the Mainstream Tunnel system is expected to have on the MSDGC flood-prone areas.

Table VIII-6
Comparison of 59th-to-Addison Segment of Mainstream to All TARP Systems - Drop Shafts and Overflow Relief Points

Component	59th-to-Addison*	All Systems**	Percent (%) of Total†
Drop Shafts	82	341	24
Overflow Relief Points	177	644	27

* Mainstream
** Mainstream, Calumet, and Lower Des Plaines[3]
† Fraction of 59th-to-Addison with respect to total for all systems.

8.2.2 Geology and Seismicity

Many of the geologic constraints placed on the construction procedures (Chapter 6.2.2) are also applicable to the long-term operation of the tunnel systems. Remedial measures taken to decrease the geologic impact during the construction phases will further add to the long-term stability of the systems operations. The impact of operations on the gross subsurface geologic and seismic characteristics of the Chicago region is considered to be negligible. Some impact of operations within a localized or restricted geologic area can be expected, and this impact could have a further impact on the operation of the system.

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[1] HEC, January 1975.

[2] HEC, August 1975.

[3] Bauer Engineering, Inc., November 1973.

The interplay of operations and geologic or seismic conditions is directly dependent upon a number of physical aspects of the various strata, or geologic structures, to be traversed by the tunnels and associated systems. These geologic constraints, discussed in detail in Chapters 2.2.3 and 6.2.2, consist of the engineering properties of the rocks, rock structure variability, bedding attitude, and geologic structures such as faults, folds, and joints within each rock unit. Awareness of specific problems posed by these geologic constraints and remedial measures taken to secure short-term stability during the construction phase of the project should be sufficient to ensure the long-term (operational) stability of the system.

(1) Geologic Effects

A number of geologic conditions would appear to have a unique impact on long-term operation of the tunnels and associated systems. These conditions do not necessarily pose a problem during the construction phase. Among these constraints are; stress changes induced by system operation or by progressive yielding of the rocks with time, the erosive or corrosive effects on the rocks of waste materials and flood waters carried by the tunnels, weathering or corrosive effects at joints or fracture zones with time, the erosive effects of rock falls moved along the length of the tunnels during periods of flooding, and the effects of a seismic event or earthquake on the tunnel and related features.

The degree of maintenance required will be a direct function of the long-term effectiveness of the rock anchoring system applied to certain segments of the tunnels.[1] Although the anchoring system can be

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[1] Harza Engineering Company (HEC), Geotechnical Design Report, "Tunnel and Reservoir Plan Mainstream Tunnel System," MSDGC, Chicago, Illinois, 1975.

relied on during tunnel excavation, tunnel operation and a progressive yielding over time resulting from stress relief will induce stress changes in the vicinity of the tunnel periphery, and the long-term reliability of the anchoring system will diminish. In these instances, rock falls would be expected, and these falls would require clean-up, rebolting, regrouting, and patching of the fallen zones. The frequency of these occurrences can become so great that future lining of the tunnel could be warranted even after start-up of operation. This provision should not be discounted. In this sense, operation of unlined tunnel segments should be regarded by the MSDGC as an "experimental," pilot venture. Most of the Mainstream Tunnel system will be lined (over 90 percent) and the rock fall impact is expected to be minimal during the operation of this system. The entire length of the 59th-to-Addison segment of the Mainstream system will be lined and no impact of rock fall on this segment is expected.

The materials carried by the tunnel systems may have an erosive or corrosive effect upon the rocks. Wetting and drying laboratory tests have indicated that almost all the rocks (with the exception of shale) will have a low chemical reactivity with the sewage.[1] However, the rocks may be highly reactive to certain industrial wastes expected to enter the tunnels and the long-term effects are not known.

It appears probable that for an unlined and unsupported tunnel, over a period of time, the thin shale partings and interbeds found in the Interreef facies of the Racine, in the Markgraf and Brandon Bridge members of the Joliet and in the Kankakee dolomites will be subject to deterioration. Deterioration would be especially rapid when the shale interbeds are subjected to alternate wetting and drying. Wherever a shaley parting or interbed occurs near the crown of a moled tunnel, it will act as a weak plane to which the crown portion will tend to break back with time, forming a flat roof. Structural weakening and fallout from the rock surrounding the tunnels would also be expected with time wherever closely spaced shale partings and joints intersect.[1]

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[1] Harza Engineering Company (HEC), Geotechnical Design Report, "Tunnel and Reservoir Plan Mainstream Tunnel System," MSDGC, Chicago, Illinois, 1975.

Rock falls would cause a decrease in the hydraulic efficiency of the tunnel. Further, irregularities in tunnel shape caused by a rock fall will be subject to more concentrated attack by erosional forces associated with flowing water. Hence, the tunnel condition could worsen rapidly in the absence of remedial measures. Moreover, the fallen rock could damage downstream tunnel sections as it is transported by the flowing waters. Additionally, since the diameter of the proposed tunnels will be greater than the approximately 17-foot diameter of existing tunnels, the, crown areas of the proposed tunnels will be somewhat less stable.

(2) Seismic Effects

The seismicity of the Chicago area has been described in detail in Chapter 2.2.4 and the construction phase-seismicity interrelations have been discussed in Chapter 6.2.3. The recurrence rate for an MMI VIII earthquake is about once for every 100 years and the last VIII earthquake was in 1909. This recurrence rate is well within the 30-to-40 year funding lifespan of the tunnel system.

A local earthquake can be generated by small (a few centimeters) movements on a fault. If the causative fault intersects the tunnel system, the minor dislocation may offset the tunnel alignment. This may alter the tunnel support systems as well as destroy the integrity of the nonstructural tunnel lining, thus exposing the surrounding rocks, especially shales, to deterioration. Rock fall in the vicinity of such a dislocation may be extensive, especially along joints or other fractures in unlined tunnels.

The impact from earthquakes generated by faults at some distance from the tunnel and associated systems is expected to be slight. Rock falls can be expected along some pre-existing joints or fracture zones. General rock fall, unrelated to existing breaks and the formation of new cracks is unlikely in light of the particle velocities required to cause breakage compared to the peak vertical velocities for all but the largest earthquakes (MMI VIII).

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[1] Harza Engineering Company (HEC), "Evaluation of Geology and Groundwater Conditions in Lawrence Avenue Tunnel, Calumet Intercepting Sewer 18E, Extension A. Southwest Intercepting Sewer 13A," Chicago, Illinois, 23 p., 1972 a.

8.2.3 Sludge Waste

Sludge solids from combined-sewer overflows will be captured by the Mainstream Tunnel system operation. Sludge from both the Mainstream and the Lower Des Plaines systems will be processed at the West-Southwest Treatment Plant and then will be disposed of in a variety of ways.

The MSDGC estimates[1] that sludge generation from the Mainstream and the Lower Des Plaines Tunnel systems will increase the sludge load of the West-Southwest plant by 70 to 100 tons per day (tpd), or by about 15 percent over the current sludge-handling rate. Ultimate disposal of the sludge solids is expected to be as follows:

Disposal Method	Sludge Production from Tunnels[2] (tpd)	1973 Sludge Disposal Rate from West-Southwest Plant (tpd)
Fulton County site	44	208
Landfill disposal	13	100
NuEarth Program	9	100
Broker sales	34	200
TOTAL	100	608

The disposal impact of the increment of sludge produced by the Mainstream and Des Plaines systems upon sludge handling and disposal practices at the West-Southwest plant is not expected to be significant.

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[1] MSDGC, private communication, February 10, 1976

[2] Mainstream and Lower Des Plaines systems.

8.3 ATMOSPHERIC RESOURCES

The impact of tunnel operation on atmospheric resources is discussed in the following sections:

- Air Quality
- Odor
- Aerosols
- Noise.

8.3.1 Air Quality

Operation of the proposed tunnel system is not likely to have any direct effects on the ambient air quality. However, there may be an indirect impact on air quality because of the use of electrical power to operate the tunnel dewatering pumps. If the required electricity is generated in a fossil fuel power plant, the pumps would require additional fuel to be burned, causing emission of air pollutants at the power plant site.

The entire tunnel system would require about 107.1 million kilowatt hours (kWh) per year to operate the pumps and aerators[1], of which about 40 million kWh would be required by the Mainstream system.[2,3]

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[1] Bauer Engineering, Inc., "Environmental Impact Statement," Preliminary Draft, prepared for the MSDGC, November 1973.

[2] Environmental Assessment Statements for Mainstream Tunnel System - Damen Avenue to Addison Street, MSDGC with assistance from Harza Engineering Company (HEC), August 1975.

[3] Environmental Assessment Statement for Mainstream Tunnel System - 59th Street to Damen Avenue, HEC, January 1975.

If the energy for the entire system is purchased from the Commonwealth Edison system, it would amount to approximately 0.1 percent of the utility's net energy generation in 1980.[1] The relatively small amount of additional fuel required to supply this energy is not likely to have significant adverse effect on the region's air quality.

Instead of purchasing it from a utility, the required power may be generated using gas turbines. The turbines could be owned and operated by the MSDGC, however, such operation would not be economical based on the present high cost of fuel oil. Therefore, the use of gas turbines is unlikely to be the choice for the proposed project. Hence, the air quality impact of gas turbine operation has not been evaluated.

8.3.2 Odor

If combined-sewer overflows are stored in the tunnels for a long period of time, anaerobic conditions may develop, resulting in odor generation. Typically three to ten days of storage are required for anaerobic conditions to develop. The tunnels are planned to be dewatered within two days of receiving combined-sewer overflows, thus eliminating the possibility of anaerobic conditions developing. Therefore, no odors should be generated during the storage of combined-sewer overflows.

If the tunnels are used to transport dry weather flows, the drop shafts would provide ample ventilation to maintain aerobic conditions and prevent generation of odor.

8.3.3 Aerosols

Aerosols are fine airborne liquid particles. These may be produced in the drop shafts when the wastewater falls at high velocity. If not properly controlled, these aerosols, made of polluted water, may escape into the atmosphere through the drop shaft opening. Since pathogenic organisms are present in the raw sewage flowing down the drop shaft, the aerosols would present a potential health hazard to nearby residents. The proposed drop shafts are designed to prevent the escape of aerosols into the atmosphere. Therefore, no adverse impacts are expected from them.

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[1] Bauer Engineering, Inc., "Environmental Impact Statement," Preliminary Draft, prepared for the MSDGC, November 1973.

8.3.4 Noise

Potential sources of noise during the tunnel operation include dewatering pumps and water falling down the drop shafts.

The pumps would be located from 250 to 300 feet underground. Noise from them could not be heard at the surface.

The water falling down the drop shafts would be aerated to cushion its impact. Thus, the noise would be minimized and it is not likely to cause significant adverse impacts. The velocity of the air leaving the drop shafts would be controlled so that no whistling sound would be produced.

8.4 COMMITMENT OF RESOURCES

Operation of the Mainstream Tunnel conveyance system,[1] will involve the yearly consumption of roughly 75 Megawatts of electric power. Assuming that coal will be burned to generate this amount of electricity, an estimate of the quantity of coal which will be consumed would be approximately 350,000 tons per year. This estimate is based on a heating value for coal of 8,500 Btu/lb and an ash content for coal of 20 percent. More typical values for coal produced in the Illinois region would be roughly 14,000 Btu/lb and 10 percent ash.[2] Thus, the consumption of 350,000 tons of coal per year is a worst-case estimate. The total amount of coal produced in the Illinois region (Illinois, Indiana, Western Kentucky and Michigan) in 1969 was 131,000,000 tons.[3] Generation of 75 Megawatts of electricity for tunnel operation would therefore involve consumption of about .3 percent of the total regional production of coal in 1969. For this reason, generation of electricity for tunnel operation is not expected to have a significant impact on area energy resources.

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[1] MSDGC, November 1973.

[2] "Potential Pollutants in Fossil Fuels", Esso Research and Engineering Company, Report prepared for U.S. EPA, Office of Research and Monitoring, June, 1973.

[3] op. cit.

IX. EFFECTS OF OPERATION ON THE MAN-MADE ENVIRONMENT

IX. EFFECTS OF OPERATION ON THE MAN-MADE ENVIRONMENT

The effects of operation of the Mainstream Tunnel system on the man-made environment are described in the following sections:

- Socioeconomic
- Land Use
- Financial Resources
- Transportation
- Other Projects and Programs.

9.1 SOCIOECONOMIC

The socioeconomic effects of operation on the man-made environment are divided here into two sections; operation-related income and operation-related employment. They are discussed below.

9.1.1 Operation-Related Income

Operation and maintenance of the Mainstream and Des Plaines tunnels have been estimated as generating approximately \$3.4 million per year in salaries and wages.[1] The maintenance and operation program is for both systems and cannot be separated out individually. This estimate assumes approximately 226 persons at an average annual salary of \$15,000.

9.1.2 Operation-Related Employment

Operation and maintenance of the Mainstream and Des Plaines tunnels are estimated to require 226 persons on a full-time basis.[2] There should be no difficulty in filling these positions from the available labor supply.

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[1] Derived from MSDGC, "Environmental Impact Statement," Preliminary Draft, November 1973, and telephone communication between Dr. Moscati of Booz, Allen and Mr. Irons of the MSDGC.

[2] Ibid.

9.2 LAND USE

The operation of the Mainstream Tunnel system would have only slight impact on land use including permanent consumption of small amounts of industrial land of varying value, some reduction of riverbank flooding, required coordination of planned riveredge facilities with shaft surface structures, and consumption of land for sludge disposal. These possible impacts are discussed in the following sections:

- Alterations Near Surface Structures
- Sensitive Resource Areas
- Sludge Disposal.

9.2.1 Alterations Near Surface Structures

The five construction shaft sites combined will consume 28.2 acres of MSDGC property, resulting in the permanent use of these sites for environmental protection. Environmental protection use would be compatible with surrounding land uses. The drop shafts and access shafts would each consume a portion of land measuring about 25 feet by 25 feet, or 625 square feet. About half of the land consumption of these 625-square-foot areas would be in MSDGC-owned, public-owned, and vacant land, resulting in their environmental protection permanent use. The next most common location of drop shafts and access shafts would be in industrial yards, industrial parking areas, and materials storage yards, causing some reallocation of industrial space. Even in the most intensively used industrial areas, this reallocation would probably only slightly interfere with operations and would not force any changes in use of industrial property. The remaining locations of drop shafts would be: nine street edges, two boat yards, and one dock. None of these land uses would be affected by system operation because the surface structure of each drop shaft can bear the loads of traffic and materials handling. Access to a drop shaft would be required so infrequently that it would cause no substantial interference with the surrounding land use. Therefore, the operation of the system can be regarded as compatible with land use near surface structures.

9.2.2 Sensitive Resource Areas

Two resource areas, Central Area Plan Development and Riverbanks, are examined in this section for potential impact from operation of the Mainstream Tunnel system.

(1) Central Area Plan Development

Two components of the Central Area Plan, the Riveredge Plan and the South Loop New Town Plan, would use some of the same lands used as drop shaft sites, and these uses should be compatible. The Riveredge Plan calls for landscaping and for pedestrian access in the area that would be occupied by drop shaft number 54. The design of the proposed improvements can probably incorporate the drop shaft structure, because it can bear pedestrian traffic. The plan also calls for development of a 3.5-acre esplanade, about half a mile long and 30 feet wide at its widest point, between Michigan Avenue and Lakeshore Drive along the south bank of the Main Branch. Four drop shafts, numbers 55, 56, 57, and 58, would be located in this esplanade. The drop shaft structures would consume only about 360 square feet of this space, and could be located along the proposed pedestrian walkway without interfering with its use. The plan also recommends the development of a residential-commercial-marina complex along Ogden Slip. Drop shaft numbers 59 and 60 would be located at the same site, and could probably be incorporated in the design by making them parts of streets or walkways.

The South Loop New Town Plan would provide for open space along the east bank of the South Branch in areas in which drop shaft numbers 44, 46, and 48 and construction shaft number 5 would be built. These shafts could probably be incorporated into the plan satisfactorily, because they would not physically interfere with the proposed use of the riverbank for open space. Drop shaft number 50 could fall within a proposed residential area or street, based on plan concepts. The location of drop shaft number 50 could most likely be adjusted easily to fit with the development plan for the South Loop.

(2) Riverbanks

To some degree, the Mainstream Tunnel system may help to alleviate the frequency of riverbank flooding and thereby could contribute to the feasibility of opening up these lands to broader development. However, insufficient data exists at the writing of this statement to determine just how much the system would alleviate the frequency of flooding. It can only be said that the quality of land in certain riverbanks along the tunnel route from 59th Street to Addison Street may be enhanced by such reduction in flooding, and that the enhancement could stimulate land use change. These riverbanks are located as stated below:

- Vacant land between the North Branch-Chicago River and North Leavitt Street (bounded by West Oakdale Avenue on the north and North Hayne Avenue on the south) in a residential section
- Undeveloped portions of the riverbanks along the Main Branch
- East bank of the South Branch in the area designated for the South Loop New Town.

The potential for land use change is similar for all of these areas; from vacant or under utilized land to landscaped open space with pedestrian access. The change at North Leavitt Street would be the easiest to effect, because it would require the least investment. In contrast, the development of landscaped open space and pedestrian access in the other two areas would require relatively great public investment. Such investments are proposed in the Central Area Plan.

9.2.3 Sludge Disposal

The disposal of sludge resulting from flows to the West-Southwest Sewage Treatment Works from the Mainstream Tunnel system would require no new sludge disposal sites. The following existing sites would receive the sludge as divided below:

MSDGC Fulton County landspreading operation	0.44
NuEarth Program (end use by consumer)	0.10[1]
Wholesaling to broker (end use by consumer)	0.34
Landfilling at sanitary landfills	0.12
Total	1.00

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[1] Value is Imhoff sludge only. Program can be expanded to accept TARP sludge.

Thus, about 20 percent of the sludge would go to the NuEarth Program and landfilling, and would remain in the metropolitan area. The consequence, for land use, would be consumption of some sludge disposal capacity at a rate somewhat greater than that under existing conditions. The increase in the rate of consumption of sludge disposal lands is balanced directly by the resultant decrease in the rate of solids deposited in the waterways. Since these solids would ultimately be dredged from the waterways and disposed of on land, the Mainstream Tunnel system would effect no change in the quantity of land used for sludge disposal.

9.3 FINANCIAL RESOURCES

This section addresses the potential economic impacts from the annual costs of operations and maintenance of the Tunnel Plan (estimated at $1 million for all three tunnel systems). It addresses the impact of these costs on the household, commercial, and industrial sectors of the MSDGC. Economic impact is assessed in terms of its effects on the tax rate structure and the manner in which operations and maintenance costs are financed.

The current method for financing operations and maintenance costs of treatment facilities is an ad valorem tax. The District is authorized to levy an ad valorem tax for operations and maintenance in an amount not to exceed $.37 per $100 of assessed valuation. The 1975 MSDGC total tax rate of $.4005 per $100 of assessed valuation included a $.2523 per $100 of assessed valuation rate for operations and maintenance and a $.1175 per $100 of assessed valuation rate for construction. In addition to the ad valorem tax, industrial discharges are subject to an MSDGC user charge imposed through the adoption of an "Industrial Waste Surcharge Ordinance" by the MSDGC Board of Trustees, December 10, 1970.

In view of the requirement for a user charge system under PL 92-500 and the authority of the State of Illinois to impose one, the potential economic affects of financing additional annual operations and maintenance costs of $1 million must be addressed on the basis of a user charge method of financing as well as an ad valorem tax method.

Table IX-1 illustrates the impact on the MSDGC tax rate of the annual operations and maintenance cost associated with the Tunnel Plan (the portion applicable to the Mainstream Tunnel system is $472,000 annually). Even on the basis of an extremely conservative posture (assuming that Tunnel Plan operations and maintenance costs must be financed commencing FY 76 and that they are escalated annually by eight percent), the impact on the MSDGC tax rate is very modest. The projected incremental impact in FY 2000 is $.0703 per $100 of assessed valuation.

Table IX-1
1976 Estimate of the Change in Property Tax Rate Attributable to the Operations and Maintenance Costs Associated With the Tunnel Plan

Fiscal Year	Annual Cost of Tunnel Plan Operations Maintenance ($ Millions)	Incremental Change in MSDGC Tax Rate ¢/$100 Assessed Valuation
1976	1.0800	04.49
1977	1.1664	04.57
1978	1.2597	04.66
1979	1.3605	04.76
1980	1.4693	04.84
1981	1.5869	04.93
1982	1.7138	05.02
1983	1.8509	05.12
1984	1.9990	05.21
1985	2.1589	05.31
1986	2.3316	05.41
.	.	.
.	.	.
.	.	.
2000	6.8485	07.03

Assumptions:

- TAX BASE (22.7 billion in 1975) is escalated at six percent annually
- Operations and maintenance costs are escalated at eight percent annually.

Economic impacts of operations and maintenance funding on a user charge basis as opposed to an ad valorem tax basis cannot be quantitatively addressed at this time. Region V EPA has awarded two grants to the MSDGC for the development of a user charge system to comply with the requirements of PL 92-500; however, the contractor has not yet made a definitive set of recommendations to the District concerning a viable user charge system. Historical experience indicates that the final user charge system will probably be based on water usage with several categories of user charge schedules. Tentative indications from the District suggest that the relative proportions of annual operations and maintenance costs currently financed by households as opposed to commercial and industrial users will be significantly shifted when the change from an ad valorem tax basis to user charge financing basis takes place. Under the current scheme (ad valorem tax), all property owners and properties pay the same MSDGC tax rate; however, assessments are divided into five major categories which include:

- Vacant land - assessed at 22 percent of market value
- Single family property - assessed at 22 percent of market value
- Rental income property - assessed at 33 percent of market value
- Commercial, industrial property - assessed at 40 percent of market value
- Miscellaneous property - assessed at 30 percent of market value.

Thus, industrial and commercial properties pay almost double the rate of households. The ultimate user charge system selected will very likely result in household/residential users paying a higher user charge (per gallon of water) than industrial and commercial users. Thus, the total portion of annual operating and maintenance costs financed by households will increase under a user charge system. In view of the relatively modest size of the operation and maintenance costs associated with the Tunnel Plan, it is extremely unlikely that the additional cost burden (resulting from the Tunnel Plan) shouldered by households under a user charge system would cause any significant impacts on household disposable income. In terms of positive economic benefits, the user charge system will provide the financial incentive for water conservation and will slightly dampen the disincentive which ad valorem taxation presents to industrial and commercial expansion within the District.

9.4 TRANSPORTATION

Potential impacts of the proposed Mainstream Tunnel system operation include, flood control on local streets, and flow regulation and sedimentation prevention in local waterways. However, the impacts of the tunnels alone, without the reservoirs, would not be significant.

Although the Mainstream Tunnel system would capture overflows from small storms, it would not prevent overflows from major storms. Since flooding of local streets occurs only during major storms, the tunnels would have an insignificant effect on preventing traffic disruption during floods. Similarly, barge traffic on the waterways is slowed down or interrupted only during major storms. Therefore, the tunnels also would not have significant beneficial effects on barge traffic.

The Mainstream Tunnel system is expected to capture approximately 75 percent of suspended solids from the combined-sewer overflows. Normally, these solids enter the waterways, and most of them eventually settle to the bottom. Continued discharge of suspended solids to the waterways would increase bottom deposits and decrease water depth. The Corps of Engineers is responsible for dredging the waterways to maintain adequate water depth for navigation, and control of suspended solids by the Mainstream Tunnel system would slow down the sedimentation rate and help reduce dredging frequency. However, the present depth of the waterways is more than adequate, and frequent dredging is not required. Therefore, the potential benefit of reduced dredging frequency as a result of the Mainstream Tunnel system would not be significant.

9.5 MAJOR PROJECTS AND PROGRAMS

The only aspects of the operation of the Mainstream Tunnel system which could possibly interfere with other projects and programs are inspection and maintenance of the shafts and tunnels. However, the frequency of such inspection and maintenance trips is too small to have any noticeable effect on the other major projects and programs, which are described in Sections 3.5 and 7.5.

9.6 COMMITMENT OF RESOURCES

The major electrical power consumer during the operational phase of TARP will be the pumping stations which pump wastewater from the tunnels to the reservoirs and from the reservoirs to the treatment plants. Approximately 100 million kilowatt hours per year is expected to be consumed in operating the eight 300-cfs and four 50-cfs pumps at the TARP planned reservoirs. In addition, the 150-horsepower aerators to be installed at the main reservoir will use approximately eight million kilowatt hours per year.

Peak power consumption, during TARP operation in 1980, is expected to be about one-half of one percent of peak requirements for the entire area in 1980. Pumping operations at the main reservoir will be the major cause contributing to the greatest peak load. Assuming the pumps at the reservoir operate at their rated capacity of 2,400 cfs, about 75 megawatts of electrical power will be consumed during peak load periods for an average year.

X. UNAVOIDABLE ADVERSE IMPACTS AND MITIGATIVE MEASURES

X. UNAVOIDABLE ADVERSE IMPACTS AND MITIGATIVE MEASURES

Impacts on the natural and man-made environments are considered adverse if they cause a significant change or stress in areas such as natural and socioeconomic resources. These adverse changes or stresses would cause the applicable medium to be less safe, healthy, abundant, aesthetically or culturally pleasing, or productive. The degree of adversity is usually measured on a case-by-case basis and focuses on the critical environmental issues that are relevant to the applicable geographic area.

10.1 NATURAL ENVIRONMENT

This section of the EIS addresses the unavoidable adverse impacts of the TARP conveyance tunnels on the natural environment of the Chicago metropolitan area. In addition, possible measures to mitigate these impacts are described. Many of these measures will be implemented by the MSDGC or MSDGC contractors as indicated in Appendices H and I. The assessment of impacts, as well as descriptions of mitigative measures, are presented in terms of the following topics:

- Water Resources
- Land Resources
- Atmospheric Resources
- Mitigative Measures.

10.1.1 Water Resources

The unavoidable impacts on water resources associated with the TARP project area are expected to include alteration of both surface water and groundwater quality. A discussion of these impacts is presented in the following sections.

(1) Water Quality

Construction runoff will further degrade surface water quality, as well as increase existing sewer system loadings in the TARP project area. Surface construction activities, such as excavating and stockpiling, introduce the potential for sedimentation or siltation of waterways and additional sedimentation loading of existing sewer systems, especially in areas which have high soil erosion characteristics. For the 59th-to-Addison segment of the Mainstream Tunnel system, most of the 82 drop shafts and 5 construction shafts will be located along the tunnel route in paved, cemented, or otherwise impervious areas. Runoff carrying sediment from spoil material stockpiles and excavated areas potentially can enter the Sanitary and Ship Canal, the existing sewers, and the Chicago River. This effect, however, is expected to be short-term.

Silt and other pollutants present in effluents resulting from tunnel dewatering operations have a short-term adverse impact on water quality if the effluent is discharged directly into surface water systems. The 59th to-Addison Mainstream Tunnel segment is expected to have a maximum total flow of approximately 4 MGD resulting from groundwater infiltration. If the infiltrated water is pumped out of the tunnel segment and discharged directly into the Sanitary and Ship Canal or the Chicago River, water quality degradation of these surface water systems will temporarily be worse than existing conditions.

(2) Groundwater

Infiltration of groundwater from the upper aquifer into the tunnels will have a short-term adverse impact on the piezometric or hydraulic pressure of the aquifer, and a grouting program will be incorporated in the construction phase of the TARP tunnel systems to mitigate this effect. Without the grouting program, groundwater inflow rates can be as high as 1.4 MGD per mile of tunnel, with the average inflow rate of groundwater for the Mainstream Tunnel approximately 0.5 MGD per mile of tunnel. These rates are sufficient to reduce the upper aquifer pressure to a critically low level. To monitor grouting integrity during tunnel operation, the MSDGC will install a number of observation wells spaced at appropriate intervals along the tunnel route. The monitoring program provides a means to determine the extent of infiltration early so that appropriate mitigative measures can be applied.

Exfiltration of wastewater, as it is conveyed by the tunnel system, may have a long-term effect on groundwater quality. The magnitude of the impact depends on how long the grouting program maintains its integrity during operation of the system. As indicated for infiltration, a tunnel grouting program will be incorporated and grouting integrity will need to be monitored. Although infiltration is expected to occur more often than exfiltration, exfiltration can become a serious problem when conveyance tunnels are nearly full. At this time, tunnel pressures will exceed inflow pressures and exfiltration will result. Pollutants present in the tunnel wastewaters, such as hazardous metals and coliform bacteria, may seep into the upper aquifer and degrade groundwater quality. To maintain surveillance and to enable timely application of remedial measures, observation or test wells will be installed, spaced appropriately along the tunnel route.

Although tunnel dewatering will be necessary during construction, the amount of water to be disposed of is not expected to cause any adverse impact on the water system for receiving this effluent. The effluent resulting from dewatering operations could be disposed of in one of several ways:

- By discharge to existing waterways
- By discharge to existing combined-sewer systems
- By injection into the upper aquifer.

Although injection of the effluent into wells would serve to retain the water in the study area, an extensive and costly recharge program would be required.

Regardless of which method is used, disposal will be preceded by effluent turbidity treatment to reduce suspended solid levels. This will be accomplished by retaining sediments in settling basins for a time sufficient to allow the sediments to settle. The quality of the effluent will be analyzed prior to discharge to determine if additional treatment is needed.

10.1.2 Land Resources

The TARP conveyance tunnels are not expected to have an adverse effect on the land-related environment of the Chicago area. These features, such as the geologic and seismic characteristics of the environment, however, may affect tunnel construction and operation with varying degrees of severity. Descriptions of these impacts as well as discussions of their magnitude are presented in the following sections.

(1) Geology

Rockfall or partings may result when the Mainstream Tunnel system tunneling operations enter shale formations or thin rock beds. During both construction and operation phases of the system, unstable conveyance tunnel conditions will prevail in these formations and beds. Stabilizing measures therefore will be incorporated and include such measures as rock bolting for short-term stability and concrete lining for long-term stability against shale partings.

Unstable conditions are caused by shale deterioration, which may occur in certain portions of the TARP tunnel systems. To show how adverse this condition can be, serious problems involving deterioration of shale have been encountered during underground natural gas exploration efforts conducted in northern Illinois. Contact of the shale with water or moist air appears to cause deterioration. Attempts to stabilize the beds and to seal the shale have largely failed in those projects for which reports are available. In a mined underground gas storage reservoir near Kankakee, Illinois, various methods were employed to stabilize the Brainard shale including rock bolts, timber shoring and wire mesh. The methods met with little success and deterioration continued after the supports were installed. The shale absorbed water around and above the rock bolts and shorings, and support from these elements was lost as raveling of the rock continued.

Similarly, attempts to use gunite to prevent or retard deterioration of the shale were unsuccessful. The small amount of water in the gunite appeared to cause the shale surface to soften so that the gunite spalled. Raveling of the shale at the Kankakee facility progressed so far that the openings were greatly enlarged, and the horizontal area of the pillars was reduced. Because of reduced bearing capacity, the pillars failed and caused further roof collapse.

Based on the problems encountered in this gas exploration effort, shale deterioration can be expected when tunnel systems are aligned within formations containing this rock material. Appropriate measures to mitigate these problems will be incorporated during construction of the TARP tunnels as necessary.

Rockfall may occur when tunnel construction activities enter fault zones, rock folds, or joints in which rock formations are weak and supportive characteristics are poor. Structural support or remedial measures will be installed by the MSDGC contractor to stabilize tunnel conditions. This effect is expected to occur during the construction phase only and, therefore, is considered short-term.

(2) Seismicity

The Mainstream conveyance tunnel will intersect numerous joints and folds along its route and will traverse minor fault zones. These geologic features are susceptible to earth movement, and seismic events of significant magnitude will result in a shearing or opening-closing movement. Tunnel alignment, concrete lining, and all stabilization measures may be altered when these events occur, and an extensive tunnel inspection and maintenance program will be required.

Although stabilization measures such as rock bolting, grouting, and tunnel lining may have a tendency to reduce the impacts, the measures are not expected to eliminate them entirely.

10.1.3 Atmospheric Resources

Unavoidable impacts on the atmospheric resources of the Chicago area are expected as a result of TARP tunnel system construction activities. The impacts will be short-term, however, and can be mitigated by applying one or more available measures. Potential air pollution and noise resulting from construction are discussed below.

(1) Air Quality

Chicago is in an air quality management area (AQMA) and overall air quality standards have been violated frequently. During worst case conditions (i.e., low wind speed and temperature inversion) hydrocarbon and nitrous oxide, as well as particulate standards were exceeded, and such instances have been frequent. With respect to air quality impacts related to the TARP tunnels, a short-term impact is expected during the construction phase. Gaseous emissions from construction vehicles and equipment with combustion engines will increase pollutant levels and degrade air quality further. Particulate content of the air during excavation activities is also expected to increase during this period. These particulate emissions will occur mostly in the vicinity of the construction shafts where rock and spoil are loaded into trucks by hoppers.

(2) Noise

Noise produced during the construction phase of TARP may affect the environment in the vicinity of construction and drop shaft sites and along the routes used by trucks transporting rock and spoil material to the disposal sites. For the Mainstream Tunnel system, however, construction and drop shaft sites will be located in commercial or industrial areas, and the impact of noise at these sites is not likely to be adverse. Similarly, noise impact along the routes used by rock and spoil disposal trucks would not be significant. The number of truck trips expected will most likely be small compared to the existing traffic volume on the planned truck routes to the disposal sites.

10.1.4 Mitigative Measures

For each impact assessment described in the previous sections, several possible mitigating measures are available, some of which will be applied by the MSDGC contractors. This section describes the typical, possible mitigative measures and presents them under the appropriate impact category.

(1) Surface Water Quality

To prevent soil from washing into waterways and sewers, a berm (trench or ridge) will be constructed around sites that are susceptible to runoff. A berm will also be constructed around stockpiles of spoil material to minimize the potential for runoff and sedimentation.

Effluents from tunnel dewatering operations should be pumped to wastewater facilities for treatment prior to discharge into waterways. The amount to be treated is small and the added load to the applicable treatment plant is considered insignificant.

(2) Groundwater Quality

To detect any adverse water quality or quantity changes in the vicinity of the TARP tunnel systems, observation wells will be constructed along the entire tunnel alignment. These wells will be installed at approximately one-half to three-quarter mile intervals. The minimum offset distance from the edge of the tunnel is approximately 30 feet to ensure that the well will be outside the grouted area. An adequate number of appropriately spaced observation wells have been installed along the Mainstream Tunnel route. However, the Lower Des Plaines and Calumet Tunnel routes will require additional wells.

The wells and the tunnel will be equipped with continuing water level recorders so that aquifer pressure can be correlated with tunnel pressure. In addition, the wells will be sampled both biweekly and after major storm events and the water samples will be analyzed for the following constituents:

pH
BOD
Chloride
Hardness
Alkalinity
NH_3 (as N)
Total Phosphorus
Phenol
COD
Cyanide
Mercury
Iron
Total Bacteria Plate Count
Coliform (MPN)*
Fecal Coliform (MPN)
Fecal Strep. (MPN)
Conductivity (or calculated TDS)

This monitoring program will provide sufficient data to detect any alterations in groundwater conditions (infiltration or exfiltration) and, thus, to enable mitigation of any adverse effects. Modification of the well spacing criteria may be necessary as the heterogeneity of the rock material changes. This will be dependent upon actual conditions prevalent at the time of construction and operation.

In the event that exfiltration of pollutants is detected in the observation wells, measures will be taken to prevent contamination of water supply pipelines. For example, the pressure of the water supply pipeline system could be raised temporarily so inside pressures are higher than outside pressures. The higher pressure inside the system will prevent infiltration of contaminated water. When flood surges in the conveyance tunnels subside to the extent that repairs can be completed, pressures inside the water supply pipeline can be reduced to normal levels. While this may result in additional use of potable water, most of that water is considered to be stored, and the potential contamination problems would be abated.

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* Most probable number.

By monitoring the observation wells on a regular basis, potential for infiltration of groundwater into the tunnel system will be detected before it occurs. The primary measure used to prevent excessive groundwater inflow is the grouting program. Therefore, the grouting program must be extensive, and effective enough during the construction phase to limit the inflow to a maximum allowable daily rate of 500 gal./in. diam./mile of tunnel. In addition, grouting integrity will be maintained throughout the operational phase of the tunnel. Grouting will be done at maximum pressures to ensure that each grout hole is properly filled. This will prevent groundwater from reestablishing seepage paths toward the tunnel. Precise records of grouting will be kept for future reference. In unlined tunnels, any future rock falls will affect the integrity of the grout applied during construction. Should these rock falls occur in zones where extensive grouting was done, infiltration/exfiltration problems may become critical. Precise grouting records will assist in ascertaining such problems.

(3) Geology

Rock bolting, grouting, and tunnel lining will be the measures applied to prevent slaking and shale parting. Concrete tunnel lining appears to be the best deterrent procedure for reducing shale deterioration and will be used in most of the TARP tunnels. Concrete lining, however, is not expected to fully eliminate this problem.

A few published reports indicate that, for limited excavating operations, slaking of shale units can be controlled and even prevented by conditioning the ventilating air circulated through the underground chambers. Temperature must be maintained within a very narrow range and relative humidity must be high. While this procedure will be of great general assistance during construction, its effectiveness is not considered to be sufficiently proven for it to comprise a totally reliable scheme in itself.

Drop and access shafts will be concrete lined, and surface reservoir excavations will use the adequate control procedures common to construction or quarrying industries. Stable ground slopes for soil and rocks will be maintained during the construction period.

The need for rock reinforcement and support in the tunnel will be determined when actual conditions are established during tunnel excavation. Installation of more support or reinforcement than is needed could result when design and installation of rock reinforcement systems are specified prior to construction. If the design specifications for rock support and reinforcement are established prior to construction; they should only be used as an estimating procedure.

(4) Air Quality

Although air pollutant emissions from construction-related vehicles and equipment cannot be avoided, preventive maintenance done on a regular basis will reduce the emissions, as well as prevent exhaust-related odors.

Fugitive dust emissions, which will also occur at construction sites, will be minimized by following acceptable construction practices. For example, excessive dust emissions will be avoided by closing the bottom of the loading hopper before emptying rock and spoil from a muck cart into a disposal truck. After the muck cart is completely unloaded, the hopper gate will then be opened to let the rock and spoil material fall gradually into the truck. Spraying the excavated material with water would further reduce dust emissions. Roads at construction sites should be paved or frequently wetted to minimize dust.

(5) Noise

Noise from construction vehicles and equipment can be minimized by using the new construction equipment and trucks which have lower emission levels and by operating them in accordance with the municipal noise ordinance.

Exhaust noise will be reduced by installing efficient exhaust silencers or mufflers and by erecting enclosures around the equipment. Erecting plywood enclosures around air compressors or a soundproof shed around exhaust fans will substantially minimize their noise.

Blasting noise can be minimized by using heavy mats on the surface above the blasting area to absorb the shock.

Overall, the impact of noise on a community can be minimized in several ways:

- Explain project benefits and mitigating measures practiced by the applicant to the affected community in public workshops and seminars.
- Notify residents in the vicinity of construction and drop shaft sites prior to a blasting operation. Explain duration and possible effects of blasting by leaflets distribution, signs, and public announcements.
- Restrict construction activities to daylight hours in sensitive public areas.

10.2 MAN-MADE ENVIRONMENT

TARP is expected to result in some unavoidable short-term impacts on the man-made environment. However, the degree of adversity will change as local environmental conditions change and will vary widely during both construction and operation periods of TARP. The following sections assess the potential impacts in general and describe the possible mitigative measures which can be applied.

10.2.1 Socioeconomic

The unavoidable adverse impacts on the socioeconomic environment that will result from the construction and operation of the Mainstream Tunnel system are described generally below.

(1) Light Glare

Construction schedules anticipate three shifts of labor on the tunneling efforts. This will require bright night lighting in construction shafts and drop shaft areas. This lighting may produce glare which will be annoying to the surrounding community, particularly in residential neighborhoods.

(2) Waste Spillage and Dispersion

The spillage of debris from trucks transporting waste from the construction sites to rock quarries or designated disposal sites will cause an adverse aethestic impact on the communities adjacent to the truck route. In addition, during wet weather conditions, the debris could enter sewer systems and nearby properties. Haulage of debris and construction materials to and from the construction access points will also create noise and vibration annoyances, as well as add to traffic volumes.

(3) Traffic Congestion

While some locations of potential conflict between construction activity and traffic flow have been identified, the adverse impacts are likely to be short-term and relatively insignificant. During construction of sewer connections, drop shafts, and collecting structures, local traffic may have to be rerouted or may have to cross temporary planking or plates in areas where surface excavations are in progress. The extent of this impact can be measured by traffic volume. As stated in previous sections of this EIS, traffic volumes presently range from 14,000 to 33,000 vehicles per day on several of the major thoroughfares associated with the Mainstream Tunnel system.

Traffic disruption will most likely occur in high-density and downtown areas where construction activity is on or near public rights-of-way. Sidewalks and traffic lanes may be temporarily eliminated or blocked to provide enough room for erection of safety barricades and storage areas.

(4) Worker Safety

Tunnel construction projects will inevitably involve injuries, disabilities, and perhaps fatalities as a direct result of construction activity. For the

Mainstream Tunnel construction the frequency rate should not be adverse when compared to any other construction project of similar type and magnitude. The potential number of disabling work injuries and fatal or permanent disabilities can be a minimum of 90 and 1, respectively.[1]

10.2.2 Land Use

The construction and operation of the Mainstream Tunnel system is not expected to affect existing land use patterns or future land use plans established for historical, cultural, archeological, and recreational purposes. Land being used for public thoroughfares, however, will be affected during construction of drop shafts, connecting lines, and collecting structures. The impact is expected to be short-term and reversible if the thoroughfares are returned to their initial condition. The major thoroughfares affected for the Mainstream Tunnel system are as follows:

- Wacker Drive lower level at Franklin Street
- Wacker Drive between Michigan Avenue and Lakeshore Drive
- West Kinzie Street between North Branch and Kingsbury Street
- North Water Street east of St. Clair Street
- Logan Boulevard near the West Diversey Parkway
- Intersection, W. Monroe and S. Jefferson Streets
- 35th Street of the South Fork of the South Branch-Chicago River
- Ashland Street at South Branch Turning Basin.

10.2.3 Financial and Labor Resources

Neither the construction or implementation of TARP is expected to have an adverse impact on present and projected financial and labor resources.

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[1] National Safety Council, "Accident Facts," Chicago, Illinois Office, 1975 edition.

10.2.4 Transportation

Trucks and automobiles associated with TARP construction activities may have an adverse short-term effect on normal traffic patterns in certain portions of the Chicago area.

Additional vehicular traffic will be generated in the vicinity of construction sites. Up to 150 trucks and 54 other vehicles (i.e., automobiles, jeeps, etc.) per day would visit each construction shaft site 24 hours a day, 312 days a year, for a period ranging from four to six years. Traffic at drop shaft sites, however, is expected to be much less: up to a total of 25 trucks over a period of three months and 10 other vehicles per day during the same period.

10.2.5 Major Projects and Programs

The proposed Core System of the Central Area Transit Project may be affected by the implementation of TARP. The potential impact concerns conflict between the proposed subway and the Mainstream Tunnel system drop shaft alignments.

10.2.6 Mitigative Measures

Many measures and alternatives are available to mitigate the adverse impacts on the man-made environment. Examples of possible measures which can be used to reduce the impact are described in this section. Some of these measures will be applied by the MSDGC or MSDGC contractors.

(1) Light Glare

Proper positioning of light fixtures can minimize glare which would affect the surrounding community. The bright lighting, however, can serve a useful purpose in commercial areas as a crime deterrent. High intensity lighting has been used successfully by many cities as a crime deterrent in high-crime-rate districts.

(2) Waste Spillage and Dispersion

Excessive solid waste spillage resulting from loading disposal trucks within the construction site will be minimized. Trucks will not be overloaded and the waste material will be dampened as necessary to prevent fugitive dust emissions. Mud and grime from truck wheels will be removed at wheel washes at all truck exits to prevent the spread of these materials to the surrounding neighborhood streets.

As indicated in the MSDGC's General Specifications for sewer construction contracts (see Appendix I), the contractor is responsible for cleanup and restoration to preconstruction condition of the construction site and areas affected. During the construction phase, the contractor is responsible for maintaining the construction sites to ensure they are free from debris and spoil material and is also responsible for keeping equipment in orderly storage areas with minimum disruption to public activities.

(3) Traffic Congestion

Public traffic flow will be given priority, particularly emergency and public service vehicles. Careful routing and scheduling of trucks hauling equipment and debris will be done to avoid peak travel periods: 7:00 to 9:00 a.m. and 5:00 to 6:30 p.m. Appropriate visible and audible warning systems for construction points of activity will be installed and an overall traffic control plan employed by the contractor. This plan will be monitored and updated as necessary with contingent routes and strategies to accommodate changes in traffic and special events (parades, holidays, street closings, bridge and light malfunctions, etc.). Local jurisdictions should be alerted and approvals should be obtained for planned truck routes and traffic control plans.

(4) Worker Safety

Strict adherence to all safety regulations and employee training programs serves as the most effective means to minimize or prevent injuries to tunnel construction and operation employees. Safety specifications established by the MSDGC are presented in Appendix H.

(5) Land Use Alterations

Land owners (private, industrial, and commercial) should be contacted well before construction begins in their respective property areas. The owners should be informed of plans such as proposed shaft locations, truck traffic routes, access requirements, and possible impacts. Other measures which will be used to prevent or mitigate the expected impacts on the man-made environment include:

- Public thoroughfares excavated for installation of connecting pipes, collecting structures, and shafts will be repaved or rebuilt to their original condition.
- The Chicago Department of Development and Planning will be advised of the relationship of proposed shaft locations with respect to the Riveredge, New Town, and South Loop plans.
- The MSDGC will notify the State of Illinois Historic Preservation officer to obtain appropriate approval of shaft locations prior to construction. Once approval has been obtained procedures will be established for halting shaft construction temporarily in the event important artifacts are found or uncovered.
- Excavation workers should be informed of potential value of finds and trained in the rudiments of identifying and preserving artifacts if the Preservation officer or designated representative cannot be present during construction of a particular shaft.

(6) Transportation

Although the number of truck trips during the peak construction period is expected to be a small fraction of the total traffic volume on most truck routes, these routes will be selected on the basis of the least impacts. The planned truck routes will avoid residential areas and other sensitive areas (i.e., hospitals, libraries), as well as congested streets, especially during rush hours. If feasible, barges can also be used along with trucks to transport rocks and spoil material on the waterways to disposal sites.

(7) Major Projects and Programs

The potential conflict between the future subway and the Mainstream Tunnel alignments can be resolved by meeting with the Chicago Urban Transportation District (CUTD) to determine whether one or more shafts or subway alignment can be modified easily. Should shaft locations near subway alignments change, care should be taken in the selection of sites to ensure that adverse impacts will not result.

XI. CONCLUSIONS AND RECOMMENDATIONS

The following is a summary of the principle conclusions of the Draft EIS, as well as recommended and suggested mitigative measures.

1. Implementation of the Mainstream Tunnel System will significantly reduce the pollutant load in the Chicago waterways. These loadings will be reduced further with the implementation of the Calumet and Lower Des Plaines Tunnel Systems. Water quality will be enhanced further with the upgrading of MSDGC's treatment facilities and the construction of the flood control aspects of the Tunnel and Reservoir Plan.

2. Significant earthquake events could adversely affect tunnel alignment and tunnel lining. Smaller earth movements could also affect the lining and grouting of the tunnels. It is therefore essential that MSDGC's inspection and maintenance program be extensive enough to insure efficient operation of the system.

3. Rock falls and partings may occur particularly in shale formations during construction. Stabilizing measures such as rock bolting are proposed to mitigate the short-term construction problems, while concrete lining will be utilized for the long term. Even with these measures, shale deterioration will continue and the inspection program should take these sensitive areas into account.

4. The rock spoil excavated from the Phase I tunnels is not expected to be marketable. Evaluation of various disposal alternatives leads to the conclusion that adequate environmentally acceptable landfill sites are available to handle the volume of rock which will be generated by the Phase I tunnels under consideration. We will rely on existing local, state and federal regulations to insure that disposal takes place in an acceptable manner.

5. Although an effective grouting program is proposed, it must be sufficiently flexible to respond to the actual conditions encountered during construction. Should the grouting not be sufficient, additional infiltration could

adversely affect the hydraulic pressure of the upper aquifer. Additionally, under surcharged conditions, exfiltration will occur, resulting in adverse impacts on the groundwater quality of the upper aquifer. Observation wells to monitor grouting integrity during operation are necessary along the entire tunnel alignment. An adequate number of wells are already in existence for the Mainstream Tunnel System. If pollutants are detected in the observation wells, additional mitigative measures must be implemented to protect the upper aquifer, including a groundwater recharge system. Chapter X discussed particular aspects of the monitoring program.

6. Since the majority of the construction shafts and drop shafts are in close proximity to area waterways, runoff from these sites could adversely affect water quality. Berms will be constructed around stockpiles of construction materials and spoil materials to preclude runoff into the waterways.

7. It is presently proposed that water pumped from the tunnels during construction be discharged directly to the waterways after a period of settling. Since the possibility of silt and other pollutants still exists after settling, it is recommended that these dewatering flows be discharged to MSDGC's intercepting system for treatment.

8. Although no known historic, architectural, or archaeological resources will be affected by the proposed project, the possibility of finding archaeological resources must be investigated by the MSDGC. This must be accomplished by contacting the State Historic Preservation Officer.

9. Conformance with applicable regulations of the Occupational Health and Safety Administration, U.S. Department of Labor, and the Bureau of Mines, U.S. Department of the Interior is essential for safety of construction workers.

10. A conflict exists between the location of several drop shafts and the plans for the Central Area Transit Project. The MSDGC must meet with the Chicago Urban Transportation District to resolve these conflicts.

11. There exists a wide range of potential adverse impacts which could develop during construction. This includes blasting noise, waste spillage, traffic congestion, light glare and fugitive dust at construction and disposal sites. While these effects could be considered insignificant any measures taken to reduce their impact would aid in public acceptability of the project. These suggested mitigative measures are discussed in Chapter X.

APPENDIX A

WATER QUALITY MONITORING DATA

Table A-1
Chicago River - Sanitary and Ship Canal
Water Quality Parameters
Average Levels for 1973[1]

Station	BOD	Susp. Solids	D.O.	Temp. °C	pH Units	Cl^-	Dis. Solids	COD
County Line Rd., W. Fork N. Br.	10.2	38.7	7.35	13.32	7.54	139.0	628.2	84.7
County Line Rd., Md. Fork N. Br.	4.6	28.6	6.34	12.14	7.56	77.1	535.2	56.7
County Line Rd., E. Fork N. Br.	4.7	39.0	7.22	13.02	7.51	77.3	535.0	56.2
East Lake Ave., Md. Fork N. Br.	10.3	41.2	8.44	13.12	7.83	91.3	530.7	65.7
Dempster St., N.B. Chicago River	7.8	37.7	7.34	12.70	7.67	98.3	536.7	59.0
Central Rd., N. Shore Channel	5.2	54.1	7.65	15.51	7.94	18.2	215.4	36.2
Touhy Ave., N. Shore Channel	9.3	48.7	7.64	15.27	7.37	94.0	496.5	65.0
Wilson Ave., N.B. Chicago River	8.2	24.2	6.70	15.64	7.45	88.7	501.8	66.8
Ohio St., N.B. Chicago River	6.8	21.6	3.41	14.90	7.32	87.3	507.6	59.2
Madison St., S.B. Chicago River	6.4	20.4	5.53	13.43	7.47	59.0	376.9	40.7
Damen Ave., S.B. Chicago River	6.1	30.7	4.49	15.58	7.48	64.4	410.1	47.0
Harlem Ave., Chgo. San. & Ship Canal	5.5	27.3	4.80	20.19	7.30	94.5	490.2	55.0
Hwy. 83 & Chicago San. & Ship Canal	7.0	19.8	3.33	18.00	7.31	107.0	485.0	58.5
Lemont Bridge Stephens Street (Grab)	6.0	19.5	1.20	27.78	7.45	82.0	431.5	60.5

Results expressed as mg/l unless otherwise indicated.

[1] Source: Appendix "C" of "Facilities Planning Study - MSDGC Overview Report," Second Revision, January 1975.

Table A-1
Continued

Station	Cd	Tot. Cr.	Cu	Fe	Ni	Pb	Zn	Hg (μg/l)
County Line Rd., W. Fork N. Br.	0.001	0.000	0.026	1.08	0.00	0.012	0.017	0.10
County Line Rd., Md. Fork N. Br.	0.001	0.001	0.015	1.00	0.02	0.007	0.008	0.11
County Line Rd., E. Fork N. Br.	0.000	0.001	0.015	1.00	0.00	0.011	0.000	0.12
East Lake Ave., Md. Fork N. Br.	0.000	0.001	0.012	1.00	0.01	0.008	0.017	0.11
Dempster St., N.B. Chicago River	0.001	0.002	0.010	1.08	0.00	0.007	0.000	0.33
Central Rd., N. Shore Channel	0.001	0.004	0.009	1.11	0.00	0.022	0.011	0.28
Touhy Ave., N. Shore Channel	0.002	0.017	0.030	1.00	0.03	0.008	0.083	0.23
Wilson Ave., N.B. Chicago River	0.000	0.009	0.022	1.00	0.02	0.002	0.025	0.09
Ohio Street, N.B. Chicago River	0.000	0.002	0.012	1.00	0.01	0.012	0.017	0.17
Madison St., N.B. Chicago River	0.000	0.001	0.010	1.00	0.01	0.005	0.008	0.08
Damen Ave., S.B. Chicago River	0.000	0.002	0.012	1.00	0.00	0.047	0.025	0.11
Harlem Ave., Chgo. San. & Ship Canal	0.000	0.016	0.011	1.00	0.06	0.012	0.025	0.17
Hwy. 83 & Chicago San. & Ship Canal	0.000	0.010	0.010	1.00	0.04	0.012	0.022	0.10
Lemont Bridge Stephens St., (Grab)	0.000	0.000	0.005	1.00	0.05	0.025	0.000	0.00

Results expressed as mg/l unless otherwise indicated.

Table A-1
Continued

Station	NH_3-N	NO_2+NO_3-N	Hex. Sol.*	SO_4^-	PO_4^-	CN^-	MBAS
County Line Rd., W. Fork N. Br.	6.29	1.92	14.7	85	4.48	N.S.	0.273
County Line Rd., Md. Fork N. Br.	0.86	1.11	15.2	79	1.67	N.S.	0.111
County Line Rd., E. Fork N. Br.	6.08	0.91	17.8	93	2.96	N.S.	0.220
East Lake Ave., Md. Fork N. Br.	2.66	1.36	14.3	88	2.06	N.S.	0.129
Dempster St., N.B. Chicago River	2.55	1.45	15.3	81	2.25	0.024	0.109
Central Rd., N. Shore Channel	0.84	0.53	15.0	31	1.07	0.080	0.095
Touhy Ave., N. Shore Channel	4.46	2.62	18.5	71	2.81	0.026	0.181
Wilson Ave., N.B. Chicago River	5.10	1.81	20.3	70	3.42	N.S.	0.233
Ohio St., N.B. Chicago River	5.49	2.30	10.2	70	3.26	0.034	0.225
Madison St., N.B. Chicago River	3.33	1.74	15.2	51	2.22	N.S.	0.190
Damen Ave., S.B. Chicago River	3.50	1.46	14.4	51	2.15	N.S.	0.212
Harlem Ave., Chgo. San. & Ship Canal	6.23	1.22	13.2	68	1.73	0.024	0.217
Hwy. 83 & Chicago San. & Ship Canal	5.47	0.91	12.9	71	1.10	0.042	0.221
Lemont Bridge Stephens St., (Grab)	6.45	1.13	15.0	102	1.65	0.040	0.099

Results expressed as mg/l unless otherwise indicated.

* Hexane Soluble Constituents.

Table A-2
Calumet River System
Water Quality Parameters
Average Levels for 1973[2]

Station	BOD	Susp. Solids	D.O.	Temp. °C	pH Units	Cl^-	Dis. Solids	COD
Wolf Lake Burnham Ave.	4.0	12.7	10.10	14.10	7.83	37.2	253.9	48.9
92nd & Ewing Ave., Calumet River	4.1	12.4	9.03	14.65	7.49	22.2	259.2	43.2
130th Street, Calumet River	4.0	22.3	7.52	15.25	7.63	80.0	383.5	57.7
IHB R.R. Bridge Grand Calumet River	15.2	60.7	2.72	16.35	7.36	116.7	591.4	98.3
Wentworth Ave., Little Calumet River	9.3	57.5	5.32	14.35	7.61	84.2	539.8	76.7
Wentworth Ave., North Creek	23.3	122.9	8.66	7.22	7.59	109.1	553.1	142.6
Joe Orr Rd., Thorn Creek	7.9	48.5	8.14	15.79	7.50	233.1	1,028.9	133.0
Indiana Ave., Calumet River	5.7	47.3	5.70	15.12	7.52	107.3	465.8	63.0
135th & Ashland Little Calumet River	8.8	73.2	5.12	13.72	7.58	206.0	912.6	97.7
Ashland Ave., Cal-Sag Channel	7.3	37.3	5.01	15.48	7.43	148.3	672.8	83.9
Cicero Ave., Cal-Sag Channel	6.6	39.7	4.18	15.43	7.37	139.7	651.8	78.5
Hwy. 83 & Cal-Sag Channel	6.2	42.3	3.89	15.22	7.48	127.3	622.1	71.0

Results expressed in mg/l unless otherwise indicated.

[2] Source: Appendix "C" of "Facilities Planning Study - MSDGC Overview Report," Second Revision, January 1975.

Table A-2
Continued

Station	Cd	Tot. Cr.	Cu	Fe	Ni	Pb	Zn	Hg (µg/l)
Wolf Lake Burnham Ave.	0.000	0.003	0.006	1.00	0.00	0.012	0.000	0.13
92nd & Ewing Ave., Calumet River	0.000	0.004	0.017	1.00	0.00	0.007	0.000	0.17
130th Street, Calumet River	0.000	0.000	0.008	1.00	0.00	0.002	0.008	0.04
IHB R.R. Bridge Grand Calumet River	0.000	0.007	0.012	1.50	0.03	0.022	0.025	0.12
Wentworth Ave., Little Calumet River	0.000	0.004	0.007	1.45	0.00	0.014	0.000	0.11
Wentworth Ave., North Creek	0.000	0.000	0.007	2.00	0.00	0.016	0.100	0.50
Joe Orr Road, Thorn Creek	0.000	0.036	0.013	1.25	0.02	0.021	0.125	0.07
Indiana Ave., Calumet River	0.000	0.003	0.007	1.25	0.00	0.002	0.000	0.07
135th & Ashland Little Calumet River	0.000	0.002	0.007	1.25	0.01	0.007	0.000	0.12
Ashland Ave., Cal-Sag Channel	0.000	0.001	0.010	1.08	0.01	0.015	0.000	0.12
Cicero Ave., Cal-Sag Channel	0.000	0.005	0.008	1.17	0.01	0.020	0.000	0.05
Hwy. 83 & Cal-Sag Channel	0.000	0.001	0.008	1.17	0.01	0.010	0.004	0.17

Results expressed in mg/l unless otherwise indicated.

Table A-2
Continued

Station	NH_3-N	NO_2+NO_3-N	Hex. Sol.*	SO_4^-	PO_4^-	CN^-	MBAS
Wolf Lake Burnham Ave.	0.24	0.18	9.3	42	0.14	N.S.	0.062
92nd & Ewing Ave., Calumet River	1.31	0.70	11.9	30	0.33	0.020	0.053
130th Street Calumet River	1.87	1.73	14.6	67	0.37	0.019	0.066
IHB R.R. Bridge Grand Calumet River	13.29	0.62	17.4	101	1.98	0.054	0.364
Wentworth Ave., Little Calumet River	2.66	1.34	14.3	111	0.80	N.S.	0.165
Wentworth Ave., North Creek	4.69	1.18	8.7	160	0.65	N.S.	0.526
Joe Orr Road, Thorn Treek	8.61	1.05	11.6	158	3.36	N.S.	0.279
Indiana Ave., Calumet River	5.48	1.24	9.7	84	0.50	N.S.	0.074
135th & Ashland Little Calumet River	4.20	1.66	17.0	144	1.49	N.S.	0.176
Ashland Ave., Cal-Sag Channel	9.08	1.43	15.1	127	1.19	0.034	0.145
Cicero Ave., Cal-Sag Channel	9.05	1.19	13.5	123	1.08	N.S.	0.158
Hwy. 83 & Cal-Sag Channel	8.65	0.94	8.5	106	1.42	0.028	0.165

Results expressed in mg/l unless otherwise indicated.

* Hexane Soluble Constituents.

Table A-3
Des Plaines River System
Water Quality Parameters
Average Values for 1973[3]

Station	BOD	Susp. Solids	D.O.	Temp. °C	pH Units	Cl^-	Dis. Solids	COD
County Line Rd., Buffalo Creek	4.8	44.5	10.01	11.40	7.55	89.5	680.1	70.5
Hintz Rd., Wheeling Drain. Ditch	5.1	59.2	9.85	11.41	7.77	89.8	666.3	60.5
County Line Rd., Des Plaines River	6.7	68.3	9.35	12.22	7.82	74.2	652.8	63.5
Palatine Rd., Des Plaines River	6.7	67.9	10.24	11.84	8.05	73.8	640.3	60.7
Central Rd., Des Plaines River	6.1	53.9	10.09	12.06	8.04	72.7	632.1	60.5
Oakton St., Des Plaines River	5.8	55.3	8.96	11.90	8.04	78.5	630.7	61.8
Belmont Ave., Des Plaines River	5.4	36.6	6.67	11.83	7.75	80.0	604.8	58.1
Roosevelt Rd., Des Plaines River	6.1	37.0	6.02	12.46	7.69	81.8	593.9	57.5
Devon Ave., Salt Creek	3.3	44.3	10.47	7.96	7.93	79.4	722.3	58.6
Wolf Road, Salt Creek	7.6	36.2	6.74	12.27	7.54	157.1	832.2	75.4
First Ave., Salt Creek	6.1	34.6	6.54	13.03	7.70	146.5	783.2	68.7
Ogden Ave., Des Plaines River	5.2	28.6	7.61	12.92	7.66	104.7	660.3	64.1
Willow Springs Rd., Des Plaines River	5.0	44.1	7.23	12.46	7.71	101.1	636.6	65.6

Results expressed in mg/l unless otherwise indicated.

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[3] Source: Appendix "C" of "Facilities Planning Study - MSDGC Overview Report," Second Revision, January 1975.

Table A-3
Continued

Station	Cd	Tot. Cr.	Cu	Fe	Ni	Pb	Zn	Hg (µg/l)
County Line Rd., Buffalo Creek	0.002	0.001	0.008	1.0	0.03	0.002	0.027	0.22
Hintz Rd., Wheeling Drain. Dtich	0.000	0.004	0.008	1.27	0.02	0.002	0.036	0.17
County Line Rd., Des Plaines River	0.000	0.003	0.007	1.18	0.01	0.004	0.027	0.23
Palatine Rd., Des Plaines River	0.000	0.000	0.006	1.09	0.01	0.011	0.000	0.15
Central Rd., Des Plaines River	0.001	0.004	0.006	1.00	0.01	0.005	0.000	0.19
Oakton St., Des Plaines River	0.000	0.001	0.006	1.18	0.03	0.010	0.000	0.12
Belmont Ave., Des Plaines River	0.000	0.001	0.006	1.00	0.05	0.002	0.000	0.25
Roosevelt Rd., Des Plaines River	0.001	0.003	0.012	1.00	0.00	0.005	0.000	0.22
Devon Ave., Salt Creek	0.000	0.000	0.004	1.00	0.00	0.011	0.000	0.00
Wolf Rd., Salt Creek	0.000	0.002	0.009	1.00	0.02	0.011	0.000	0.19
First Ave., Salt Creek	0.000	0.002	0.010	1.09	0.01	0.010	0.000	0.10
Ogden Ave., Des Plaines River	0.000	0.002	0.009	1.00	0.01	0.006	0.000	0.11
Willow Springs Rd., Des Plaines River	0.000	0.004	0.012	1.18	0.02	0.020	0.000	0.18

Results expressed in mg/l unless otherwise indicated.

Table A-3
Continued

Station	NH_3-N	NO_2+NO_3-N	Hex. Sol.*	SO_4^-	PO_4^-	CN^-	MBAS
County Line Rd., Buffalo Creek	0.81	1.94	13.3	106	0.61	N.S.	0.195
Hintz Rd., Wheeling Drain. Ditch	0.32	4.13	10.5	100	0.48	N.S.	0.141
County Line Rd., Des Plaines River	0.48	1.58	10.5	95	0.66	N.S.	0.068
Palatine Rd., Des Plaines River	0.41	1.40	11.0	94	0.49	0.004	0.071
Central Road, Des Plaines River	0.43	1.22	12.6	92	0.38	N.S.	0.074
Oakton St., Des Plaines River	0.39	1.35	12.7	91	0.38	N.S.	0.081
Belmont Ave., Des Plaines River	0.74	1.16	10.9	90	0.40	0.008	0.203
Roosevelt Road, Des Plaines River	0.59	1.15	11.4	88	0.50	0.016	0.191
Devon Ave., Salt Creek	0.34	0.61	8.3	123	0.19	N.S.	0.050
Wolf Road Salt Creek	2.92	2.10	12.0	105	1.49	N.S.	0.290
First Ave. Salt Creek	1.63	2.56	9.8	111	1.32	0.019	0.241
Ogden Ave., Des Plaines River	0.97	1.80	10.1	87	0.85	N.S.	0.229
Willow Springs Rd., Des Plaines River	1.21	1.59	13.3	95	0.62	0.009	0.197

Results expressed in mg/l unless otherwise indicated.

* Hexane Soluble Constituents.

Table A-4
MSDGC Survey of Bottom Deposits

Sample No.	LOCATION	WATERWAY DATA Width A*	Depth Water B*	Depth Deposit C*	FIELD OBSERVATION	LABORATORY ANALYSIS COMMENTS		Volatile Solids%
1.	Lake St. (U.S. 20) @25.0 mi. Salt Creek Trib.	10'	0.5'	N.A.	Bottom frozen, used power auger for sample	as recd.	Large rocks, sand, putrid, euximic** water	8.8
						Dry	oil spot-grey	
						Ash	Brown color	
2.	S. Lake St. (U.S. 20) Bridge E-PUmping Sta. @ 23.5 mi. Salt Creek	20'	1.5'	N.A.	Bottom frozen, used hand auger sampler	as. recd.	Brown, sand, mud mixture, stagnant odor	5.0
						Dry	Grey	
						Ash	Brown color	
3.	North Ave. (U.S. 64) Bridge @ 21.7 mi. Salt Creek	30'	2.25'	1'	Partly frozen	as recd.	Black, sand-mud mixture, putrid, large stones	4.3
						Dry	Black	
						Ash	Brown color	
4.	Roosevelt Rd. (U.S. 38) Bridge Frontage Rd (N) @17.2 mi. Salt Creek	60'	4.0'	3.0'	Large amount deposit by piers, depth varies	as recd.	Black mud, plant debris, sulfide odor euximic	12.2
						Dry	Black	
						Ash	Brown color	

*See Typical Waterway Detail Table

**Black or brown in color, having a sulphide odor, and formed by or undergoing change by an anerobic process.

Table A-4
Continued

Sample No.	LOCATION	WATERWAY DATA			FIELD OBSERVATION	LABORATORY ANALYSIS		
		Width A	Depth Water B	Depth Deposit C		COMMENTS		Volatile Solids%
5.	York Rd. Bridge @11.8 mi. Salt Creek	45'	3.0'	2.0'	Ice very thin deposit same as sample 4	as. recd.	Black mud, small pebbles, sulfide odor, euximic	9.2
						Dry	Black	
						Ash	Brown color	
6.	Brandon Rd. Bridge @13.1 mi. Des Plaines River	200'	4'	3'	Botton varies	as recd.	Black mud, gravel putrid, plant debris, euximic	13.6
						Dry	Black	
						Ash	Brown	
7.	MSDGC North Side T.P. @24.0 mi. Chicago San. Ship Canal	35'	3'	2.5'	Very dark soft, strong odor	as recd.	Grey mud, plant debris, putrid, euximic	6.1
						Dry	Grey	
						Ash	Brown	
8.	Pratt Rd. @11.0 mi. North Shore Channel	40'	5'	2'	Same as sample 7	as recd.	Grey mud, plant debris, putrid euximic	4.1
						Dry	Grey	
						Ash	Brown	

Table A-4
Continued

Sample No.	LOCATION	WATERWAY DATA			FIELD OBSERVATION	LABORATORY ANALYSIS		
		Width	Depth Water	Depth Deposit		COMMENTS		Volatile Solids%
		A	B	C				
9.	2600' S.W. of Stickney T.P. @24.0 mi. Chicago San. Ship Canal	150'+	25'	N.A.	Too deep to probe. Large gravel	as recd.	Highly putrid odor, gravelly sand, euximic	6.0
						Dry	Black	
						Ash	Brown	
10.	Harlem Ave. @23.4 mi. Chicago San. Ship Canal	150'+	25'	N.A.	Too deep to probe. Sample oily	as recd.	Sandy mud mixture, plant debris, sulfide odor, euximic	4.8
						Dry	Black	
						Ash	Brown	
11.	U.S. 12 & 20 @19.0 mi. Chicago San. Ship Canal	150'+	25'	N.A.	Same as sample 10 Oily smell	as recd.	Large rocks, euximic water layer	23.5
						Dry	Black	
						Ash	Brown	
12.	106th St. @2.5 mi. Calumet River	125'+	30'	N.A.	Too deep to probe. Sample dark & oily	as recd.	Sand-mud mixture, putrid, euximic	9.2
						Dry	Black	
						Ash	Brown	

Table A-4
Continued

Sample No.	LOCATION	WATERWAY DATA			FIELD OBSERVATION	LABORATORY ANALYSIS		
		Width	Depth Water	Depth Deposit		COMMENTS		Volatile Solids%
		A	B	C				
13.	Torrence Rd. @ 5.3 mi. Calumet River	125'+	30'±	N.A.	Same as sample 12 middle of River has clay & gravel sample taken 40' from east bank	as recd. Dry Ash	Sand, putrid, euximic Brown Brown	3.5

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1 MSDGC - Alternative Management plans for control of flood and pollution problems due to combined sewer discharges in the general service area of the Metropolitan Sanitary District of Greater Chicago, November 1973, pp. 131-134.

Table A-5
Chemical Analyses of Ground Waters[1]
(Water Analyses Made By the Illinois State Water Survey)

Aquifer	Fe (ppm)	SiO_2 (ppm)	F (ppm)	Cl (ppm)	NO_3 (ppm)	SO_4 (ppm)	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ (ppm)	Total dissolved minerals (ppm)	Turbidity (ppm)	Odor
Silurian	78	12.1	1.4	31	0.6	16.0	296	134	408	1880	0
"	296	-	2.6	46	0.5	8.0	306	136	432	7980	0
"	0.7	-	1.6	4	0.3	43.6	222	62	318	2	0
"	0.7	-	1.4	8	1.8	172.6	206	68	480	6	0
"	0.1	-	0.4	13	0.3	11.9	132	114	180	1	H_2S
"	0.8	-	1.6	22	0.3	0.6	172	14	240	2	0
"	64	-	1.4	33	1.7	28.2	340	144	443	3080	0
Galena-Platteville	0.7	-	3.5	210	1.8	158.8	336	110	952	2	H_2S
"	6.4	-	1.4	385	0.2	661.5	208	576	1872	19	0
"	0.5	-	1.4	200	0.2	680.9	232	690	1561	2	0
"	8.4	-	1.2	380	0.9	643.6	216	548	1732	50	0
"	0.5	-	1.8	185	1.8	363.1	268	266	1111	3	0
"	6.2	-	1.8	420	0.8	885.7	214	795	2206	36	0
"	17	-	1.4	265	0.3	652.3	212	620	1567	50	0
St. Peter	0.5	-	1.2	275	0.2	736.2	218	745	1727	2	0
Prairie du Chien, Eminence, and Potosi	0.4	-	1.4	245	0.6	734.4	212	795	1680	3	0
Cambrian-Ordovician	0.4	-	1.6	230	1.4	725.7	214	750	1676	2	0
Franconia	0.3	-	1.6	240	0.2	729.0	208	760	1692	2	0
Ironton-Galesville	0.9	-	1.0	200	0.2	690.9	222	728	1572	3	0

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[1] Buschbach and Heim, 1972.

Table A-6
Chemical, Physical, and Biological Analyses of Water From Test Wells[1]

	WELL SITES							
Constituent[1]	NW Side of McCook Quarry	NE Side of McCook Quarry				1 Mi. South of Thornton Quarry	1/2 Mi. West of Thornton Quarry	SE Corner of McCook Quarry
Date Sample Collected	11/1/74	9/13/74	9/19/74	9/20/74	9/21/74	9/5/74	10/4/74	11/10/74
I. General Data								
pH[2]	7.8	7.7	8.1	7.6	7.6	8.5	8.25	7.8
Color[3]	10	1167	2500	2500	3000	11	4.0	23
Turbidity[4]	-	600	40	40.5	45	73	-	-
Conductivity[5]	920	4190	4990	4000	4000	560	1100	1290
Temperature[6]	53.5	56	57.5	56	56	54	53.5	53
II. Cations - Heavy metal ions								
Iron (Fe) - total dissolved[7]	0.2	3.5	1.87	1.80	1.55	0.5	0.2	0.2
Iron (Fe) - total	0.3	18	2.11	2.00	1.60	6	0.2	0.6
Manganese (Mn) - total	-	-	0.10	0.09	0.06	-	-	-
Chromium (Cr) - total	-	-	0.02	0.02	0.02	-	-	-
Chromium (Cr) - hexavalent	-	-	0.02	0.02	0.02	-	-	-
Copper (Cu)	-	-	0.138	0.034	0.034	-	-	-
Lead (Pb)	-	-	0.27	0.08	0.19	-	-	-
Mercury (Hg)[8]	-	-	0.5	0.5	0.5	-	-	-
III. Cations - Alkali earths and metals								
Calcium (Ca)	148	135	158	156	167	80	202	185
Magnesium (Mg)	70	130	90.9	95.5	95.5	10	80	110
Sodium (Na)	35	633	569	569	534	135	18.2	76
Potassium (k)	4	233	178	178	194	6	12.1	13
Ammonia Nitrogen (NH_3)	-	96	224	155	157	0.5	-	-
IV. Anions								
Sulfate (SO_4)	245	87.25	76.0	86.0	80	40	220	400
Chloride (Cl)	62	558	510	504	496	18	39	120
Nitrite (NO_2)	-	-	0.125	0.150	0.150	-	-	-
Nitrate (NO_3)	1	-	0.625	0.600	0.600	0.08	0.3	1
Nitrogen (N) - total dissolved	-	217.21	242	222.7	217.6	1.0	-	-
Orthophosphate (PO_4)	-	2.8	2.16	2.03	1.90	1	-	-
Phosphorus as PO_4	-	2.9[9]	2.36[9]	2.22[9]	2.46[9]	1	-	-
Cyanides as CN	-	-	0.04	0.038	0.032	-	-	-
V. Organic, nonionic, and calculated values								
Phenolic material as C_6H_5OH	-	-	0.004	0.006	0.005	-	-	-
Surfactants	-	7.13	1.26	1.14	1.20	0.04	-	-
Total suspended solids (TSS)	-	-	5	12	9	-	-	-
Total dissolved solids (TDS)	924	2656	2788	2730	2664	451	937	1420
Volatile suspended solids (VSS)	-	-	2	2	3	-	-	-
Hardness as $CaCO_3$ - total	659	878	582	590	572	242	834.1	916
Alkalinity as $CaCO_3$	377	1935	2078	2033	2010	260	377	422
Saturation index[10]	+ 0.4	+ 1.0	+ 1.5	+ 1.0	+ 1.0	+ 0.8	+ 1.0	+ 0.6
VI. Biochemical								
Biochemical Oxygen Demand (BOD)	-	-	16	35	23	-	-	-
Chemical Oxygen Demand (COD)	-	695	595	542	527	16	-	-
Sulfides (H_2S)	-	-	0.39	0.24	0.32	-	-	-
Total Coliform[11]	1	-	20,000	20,000	19,000	-	-	1
Fecal Coliform[11]	1	-	10	10	10	-	-	1
Fecal Streptococci[11]	-	-	10	10	10	-	-	-

[1] All values are reported as mg/l except as otherwise noted
[2] pH units
[3] Pt - Co units
[4] J T units
[5] umhos @ 25°C
[6] °F
[7] Filtered through 0.45 membrande filter.
[8] Values reported as ppb
[9] Values reported in mg/l as P
[10] Assume temp. - 55°F
[11] Values reported as organisms/100ml.

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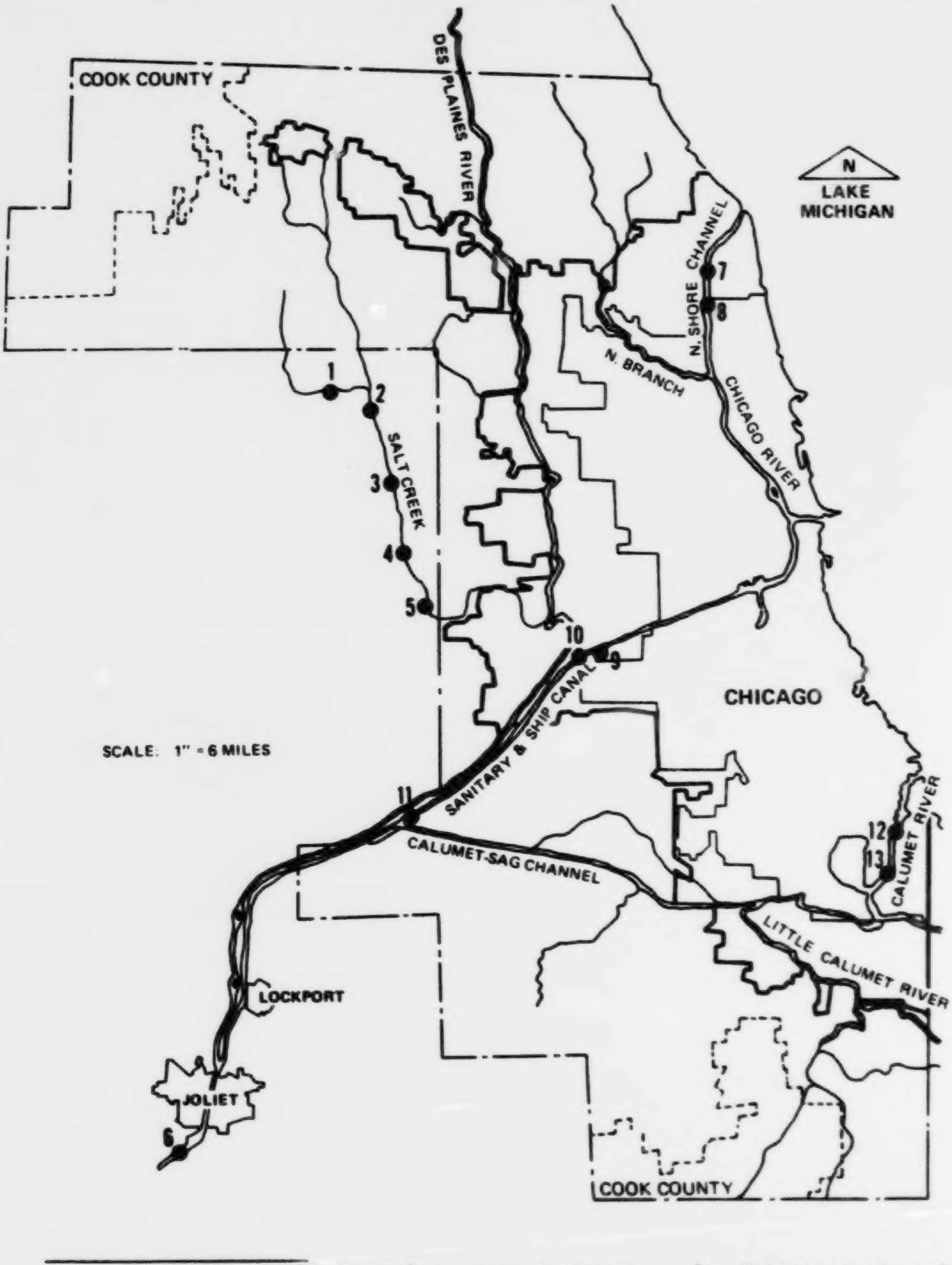
2 HEC, 1975.

FIGURE A-1
Location of Sampling Sites
for Waterway Bottom Deposits[1]


COOK COUNTY
DES PLAINES RIVER
N
LAKE MICHIGAN
N. SHORE CHANNEL
7
8
N. BRANCH
CHICAGO RIVER
1
2
SALT CREEK
3
4
5
10
9
CHICAGO
SANITARY & SHIP CANAL
SCALE: 1" = 6 MILES
11
CALUMET-SAG CHANNEL
12
13
CALUMET RIVER
LITTLE CALUMET RIVER
LOCKPORT
JOLIET
6
COOK COUNTY

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[1] The MSDGC, Environmental Assessment Statement for Mainstream Tunnel System, Damen Avenue to Addison Street, August 1975. p. v-40.

KEY TO FIGURE A-2
The Metropolitan Sanitary
District of Greater Chicago

TREATED RUNOFF PLANTS INDEX

Map Code	Name
R-1	FISHER BODY DIVISION 79th Street & Willow Springs Road Willow Springs (Settling lagoons with oil separation)
R-2	INTERNATIONAL HARVESTER 10400 W. North Ave., Melrose Park (Oil separation, aeration, filtration)
R-3	MATERIAL SERVICE CORP. YARD #19 47th St. & Plainfield, McCook (Oil separation)
R-4	NORTH AMERICAN CAR CO. Off Old Sag Road, Lemont (Oil separation)
R-5	O'HARE INTERNATIONAL AIRPORT (Oil separation systems and aeration)
R-6	FRITZ CARTAGE 138th & Ashland Ave. Riverdale
R-7	REYNOLDS METALS 1st Ave. & 49th St. McCook

KEY TO FIGURE A-2
Continued

DOMESTIC WASTE PLANTS INDEX

Map Code	Name
D-1	CAR CARRIERS CORP., 13101 S. Torrence Ave., Chicago (Activated sludge & sand filter)
D-2	CECO FABRICATING CORP., Ceco St. Romeoville, Ill. (Activated sludge)
D-3	ELK GROVE MOBILE HOMES, 941 W. Higgins Rd., Elk Grove Village (Activated sludge & sand filter)
D-4	FRANCISCAN SISTERS, 1210 Main St., Lemont, Ill. (Activated sludge system)
D-5	HOLY FAMILY VILLA, 123rd St. & Will Cook Rd., Lemont. (Imhoff tank, sand filter & polishing pond.)
D-6	HOLY SPIRIT CONVENT, Waukegan & Willow Rd., Northbrook. (Imhoff tank & sand filter)
D-7	J.P. KENNEDY SCHOOL, 123rd St. & Wolf Rd., Palos Park. (Imhoff tank & sand filter)
D-8	LEHMAN TRAILER PARK, 500 W. Touhy Ave., Bensenville. (Activated sludge)
D-9	LEMONT MANUFACTURING CO. Ceco St. & Stephens St., Lemont. (Activated sludge)
D-10	MATTERHORN SUPPER CLUB, 123rd & Rt. 45 Palos Park (Aeration, oxidation pond, sand filter)
D-11	MOUNT ASSISSI ACADEMY, 1602 Main St. Lemont (Oxidation pond)
D-12	OASIS MOBILE HOMES, 7500 N. Elmhurst Rd., Bensenville. (Activated sludge)
D-13	PARADISE TRAILER COURT. Rt. 83 & Rt. 30 Chicago Heights (Activated sludge)

KEY TO FIGURE A-2
Continued

DOMESTIC WASTE PLANTS INDEX

Map Code	Name
D-14	PLEASANTDALE SCHOOL, 75th St. & Wolf Rd. Pleasantdale. (Trickling filter unit)
D-15	ST. VINCENT DePAUL SEMINARY, 127th & Rt. 171, Lemont (Imhoff tanks, oxidation pond)
D-16	SPRING LAKES MOBILE HOMES, 100 First St. Bartlett (Activated sludge)
D-17	STANDARD OIL (O'HARE TERMINAL), 2201 S. Elmhurst Rd., Des Plaines (Activated sludge & filtration)
D-18	TOUHY MOBILE HOMES, INC., 400 W. Touhy Ave., Des Plaines (Activated sludge)
D-19	TRAILER RANCH, INC., 573 S. Milwaukee Ave., Wheeling (Activated sludge)
D-20	VILLA WEST SUBDIVISION, 135th St. & 86th Ave., Orland Park (Activated sludge)
D-21	COG HILL COUNTRY CLUB, 119th & Archer Lemont

KEY TO FIGURE A-2
Continued

INDUSTRIAL WASTE PLANTS INDEX (Exceeding 10,000 gallons per day)

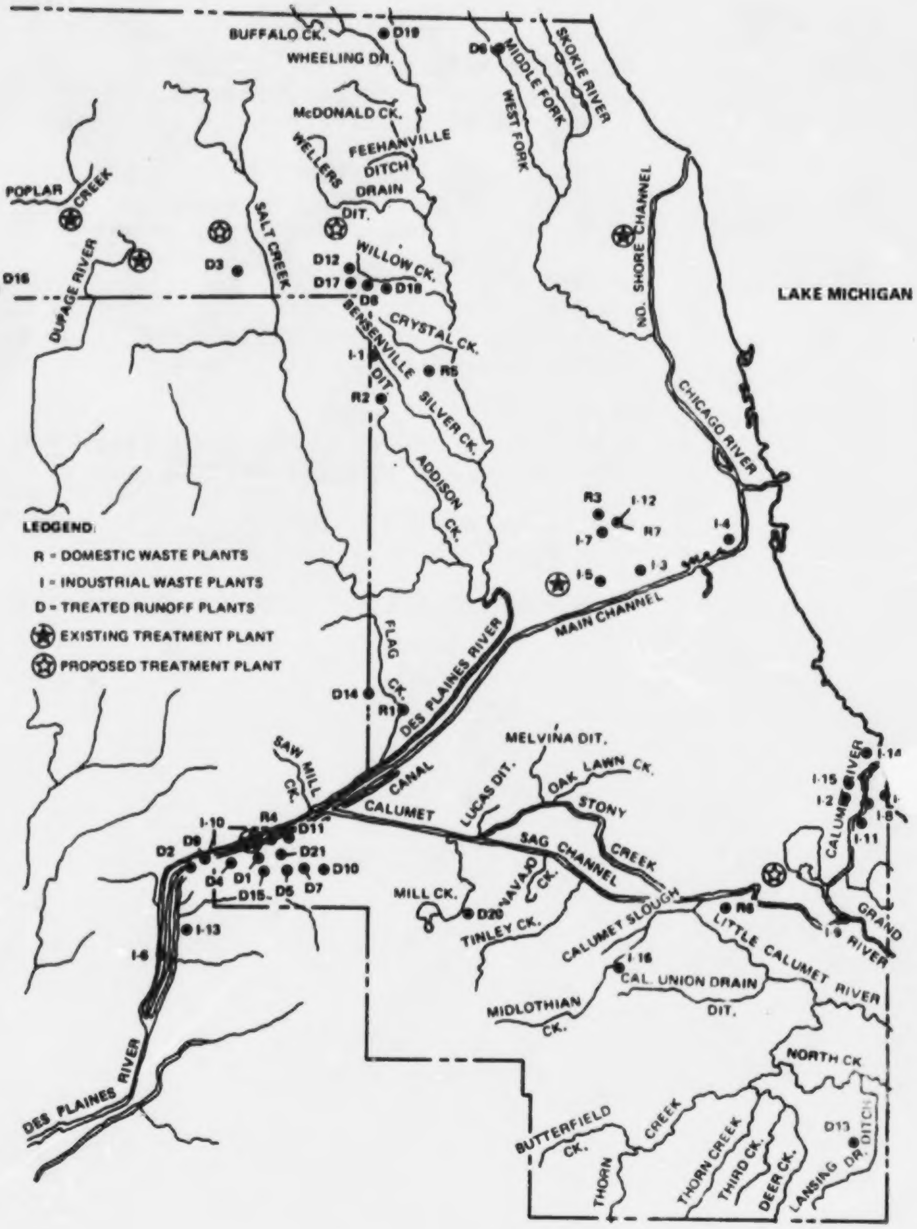
Map Code	Name
I-1	CLOW CORPORATION, 1050 E. Irving Park Rd., Bensenville, Illinois (Holding pond with oil separation)
I-2	COMMONWEALTH EDISON, CALUMET 3200 E. 100th St., Chicago (Settling basins)
I-3	COMMONWEALTH EDISON, CRAWFORD 3501 S. Pulaski, Chicago (Settling tanks and filtration)
I-4	COMMONWEALTH EDISON, FISK 1111 W. Cermak, Chicago (Settling pits)
I-5	COMMONWEALTH EDISON, RIDGELAND 4300 S. Ridgeland, Stickney, Illin. 60405 (Settling pit & filtration)
I-6	COMMONWEALTH EDISON, ROMEOVILLE. 135th St. & C.S.S. Canal, Romeoville. (Settling ponds and filtration)
I-7	ELECTRO-MOTIVE DIV., GENERAL MOTORS. 9301 W. 55th St., McCock (Oil retention pond & separator with overflow)
I-8	INTERLAKE STEEL, CHICAGO PLANT 10730 S. Burley Ave., Chicago (Chemical precipitation with total recycle)
I-9	INTERLAKE STEEL, RIVERDALE 135th St. & Perry, Riverdale (Settling and sand filters)
I-10	LEMONT MANUFACTURING Ceco St. & Stephens St., Lemont (Settling tanks and filtration)
I-11	REPUBLIC STEEL CORP. (CHICAGO DIST.) 116th St. & Burley Ave., Chicago (Chemical flocculation & settling with filtration)

KEY TO FIGURE A-2
Continued

INDUSTRIAL WASTE PLANTS INDEX (Exceeding 10,000 gallons per day)

Map Code	Name
I-12	REYNOLDS METALS 1st Ave. and 49th St., Brookfield (Chemical flocculation and clarification)
I-13	UNION 76 OIL REFINERY 135th St. & New Ave., Romeoville (Activated sludge, oxidation ponds)
I-14	UNITED STATES STEEL CORP. 3426 E. 89th St., Chicago (oil separation chemical flocculation with clarification and filtration)
I-15	WISCONSIN STEEL CORP. 106th St. & Torrence Ave., Chicago (Solids, oil & cyanide oxidation systems)
I-16	WILLIE BROS., CO., INC., 4930 W. 159th St., Oak Forest
I-17	COMMONWEALTH EDISON, STATE LINE GENERATOR

FIGURE A-2
Industrial and Privately-Owned Treatment Plants Within the MSDGC Service Area[1]


LAKE MICHIGAN
BUFFALO CK.
D19
WHEELING DR.
D6
MIDDLE FORK
WEST FORK
SKOKIE RIVER
McDONALD CK.
WELLERS
FEEHANVILLE
DITCH
DRAIN
DIT.
POPLAR
CREEK
SALT CREEK
DUPAGE RIVER
D16
D3
D12
D17
D8
D18
WILLOW CK.
CRYSTAL CK.
BENSENVILLE
DIT
I-1
R5
R2
SILVER CK.
ADDISON
CK.
NO. SHORE CHANNEL
CHICAGO RIVER
R3
I-12
I-7
R7
I-4
I-5
I-3
MAIN CHANNEL
LEDGEND:
R = DOMESTIC WASTE PLANTS
I = INDUSTRIAL WASTE PLANTS
D = TREATED RUNOFF PLANTS
EXISTING TREATMENT PLANT
PROPOSED TREATMENT PLANT
FLAG
CK.
D14
R1
DES PLAINES RIVER
SAW
MILL
CK.
CANAL
CALUMET
MELVINA DIT.
LUCAS DIT.
OAK LAWN CK.
STONY
CREEK
SAG CHANNEL
I-10
R4
D11
D9
D2
D21
D1
D10
D4
D15
D5
D7
I-13
I-6
MILL CK.
D20
NAVAJO
CK.
TINLEY CK.
CALUMET SLOUGH
R6
I-16
CAL. UNION DRAIN
DIT.
LITTLE CALUMET RIVER
MIDLOTHIAN
CK.
I-14
I-15
I-2
I-8
I-11
CALUMET RIVER
GRAND
I-9
RIVER
NORTH CK
BUTTERFIELD
CK.
CREEK
THORN
THORN CREEK
THIRD CK.
DEER CK.
LANSING
DR.
DITCH
D13
DES PLAINES
RIVER

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[1] Industrial Waste Loadings and Industrial and Private Treatment Plant Locations, Appendix B of "Facilities Planning Study - MSDGC Overview Report," Revised, Jan. 1975.

APPENDIX B

STRATIGRAPHY DESCRIPTION
FOR THE
CHICAGO AREA

APPENDIX B

STRATIGRAPHY DESCRIPTION FOR THE CHICAGO AREA

1.1 QUATERNARY SYSTEM

The Quaternary System comprises all rocks and sediments younger than the Tertiary. The Pleistocene deposits underlie the surficial soils and any artificial fill materials in the project area. These materials are almost entirely Wisconsinan in age and are generally divided into five substages: (1) The Altonian, which includes till and outwash buried by younger drift and found mainly in the northwestern part of the area; (2) the Farmdalian, which includes local deposits of peat, organic silts, and lake deposits; (3) the Woodfordian, which includes most of the Wisconsinan till, outwash, and lake deposits in the area; (4) the Twocreekan, which includes local lake and swamp deposits in the Lake Chicago sediments; and (5) the Valderan, which includes lake deposits in a small part of the Lake Chicago plain and part of the youngest sand and gravel deposits in the Des Plaines and Illinois Valleys.[1]

The Altonian substage has but one subdivision; the Winnebago formation. The Winnebago consists of silty and sandy tills, and a silt member with peat. It is found to the northwest and west of Chicago. The Farmdalian substage consists of the Robein silt which has been encountered in borings in the northwestern part of the area.

Sediments of the Woodfordian substage or of Woodfordian-Valderan age comprise the vast majority of sediments in the Chicago area. Because of the complexity of glacial sedimentation, the deposits of the Woodfordian glaciers are also classified into morphostratigraphic units called drifts. Each drift or moraine contains parts of all of the Woodfordian formations. There are 27 named moraines and at least 19 stands of ice front are required to account for the Chicago moraines.

The Wedron formation of Woodfordian age averages 100 feet thick throughout the area but may be as thick as 300 feet. There are five till members that range from sandy and silty tills to clay tills and all have particles the size of pebbles, cobbles, and boulders. The tills also contain beds of waterlaid sand, gravel, or silt.

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[1] Willman, H.B., "Summary of the Geology of the Chicago Area", Illinois State Geological Survey, Circular 460, 1971.

The most important of the morphostratigraphic moraines of Woodfordian age are the Valparaiso drifts, Tinley drifts, and the Lake Border moraines. The Valparaiso drifts are clayey, silty, and sandy tills with intermixed gravel and sand deposits. The Tinley drift is large clayey till with interbedded silts and clays. The Lake Border drifts are clayey tills with some fine sandy gravels.

Several Woodfordian age formations continued to be deposited during Twocreekan and Valderan time. The prominent units are the Henry formation and the Equality formation. The Henry formation is predominately sand and gravel with local beds of silt and till. The Equality formation is composed of silt, sand, gravel, and clay deposits that accumulated in glacial lakes. Much of the eastern section of the Chicago area is surfaced with Equality sediments.

A number of Wisconsinan sediments are found as small deposits throughout the region and include the Richland loess, Parkland sand, the Grayslake peat, and floodplain deposits collectively called the Cahokia Alluvium.

Natural gas has been encountered on rare occasions in the glacial drift during drilling operations in the Chicago area. One soil-boring for a building foundation encountered a gas flow which is reported to have continued for 24 hours. No gas was found in any holes drilled during the 1968, 1971, or 1974 exploration programs.

2.1 PALEOZOIC

- Silurian. The Silurian forms the bedrock surface in much of the Chicago region. The Silurian present in the area falls into the Niagaran and Alexandrian series. The uppermost Cayugan series is not present.

- Niagaran series. The Niagaran series is composed of four formations; the Racine, Sugar Run, Waukesha, and Joliet.

- Racine formation. The Racine formation, the youngest, most lithologically variable, and stratigraphically highest of the bedrock formations of the Chicago area (except for some rocks in the Des Plaines disturbance), consists of dolomite with some chert. North and west of Chicago the thickness of the formation thins to zero feet. Drill hole data indicate that the thickness increases toward the south and east, reaching 70 feet in Wilmette, 213 feet at Roosevelt Road and Lake Shore Drive, and a maximum of about 360 feet in the Thornton area. The thickness of the formation, as found in drill holes, ranges from zero to 358 feet with the thickness in the majority of holes ranging from 100 to 175 feet.

The lithologic variability of the Racine dolomite can be traced to its origin. During its deposition, the Chicago area was occupied by a large complex of coral reefs, which were as large as several miles in diameter. Three varieties, or facies, of the Racine are recognized in the area: the reef, reef-flank, and interreef facies. Some zones within the Racine display thin alternating layers of both the reef and interreef facies within a short vertical distance.

- Reef. This facies is a light to medium gray, exceptionally pure (non-argillaceous), massive, porous, medium to coarsely crystalline dolomite. Petrographic analyses show the crystals to be interlocking and from 0.1 to 0.2 mm in size.

  Irregularly shaped vugs, to a 0.25 foot maximum dimension, are abundant in the reef facies. Most of the vugs are unlined, but a few are lined with secondary calcite, pyrite, or quartz. A black asphaltic residue is found locally in the uppermost part of the formation.

  Reef facies constituted approximately 66 percent of the Racine drilled along the Mainstream Tunnel System, and it constituted the basal portion of the Racine formation in all but three holes drilled during the subsurface exploration programs. Widespread and relatively thick sections of interreef rock are found, overlying the basal reef in some areas.

- Reef-flank. The reef-flank deposits are transitional between the massive reef facies and the thinner and finer grained beds of the interreef facies. The reef-flank facies is found on the margins of some of the larger reefs and is characterized by beds that dip as much as 45 degrees away from the central reef core. Dipping beds crop out and also occurred in cores in the Thornton and the McCook areas.

- Interreef. This variety of the Racine formation is composed of argillaceous, silty dolomite. Locally, it contains chert in the form of scattered, porous nodules and as thin beds. Sporadic thin partings and lenses of green shale also occur.

  Rock in the Racine, as seen in the cores, is generally fresh. In a few holes, however, the upper few feet of rock is weathered. The weathered zone is generally limited to the upper 10 feet, but locally extends to a depth of 20 feet. Staining on joint surfaces occurs in a few holes to greater depths. Weathered zones of a foot to a few feet in thickness occur at depth in a few holes.

  Core recovery is usually very high in the Racine, on the order of 95 to 100 percent, and the Rock Quality Designation (RQD) is uaually higher than 85 percent. Core recovery and RQD are both reduced at the bedrock surface where the rock is weathered and closely fractured.

- Sugar run formation. In 1973 the Illinois State Geological Survey designated a well-bedded dolomite comprising the basal 25 feet of the Racine formation as the Sugar Run formation. The unit is lithologically similar to many interreef deposits, and although readily observed in outcrop in the Chicago area, it is difficult to identify in cores, and may be locally absent.

- Waukesha formation. The Waukesha formation is a slightly silty, dense to finely vuggy, fine grained dolomite that occurs in smooth surfaced beds that commonly are 2 to 8 inches thick but are locally as much as 3 feet thick. It is light brownish gray and weathers brown. It is exposed at Joliet, in the Des Plaines River bluffs northward from Joliet and in deep quarries at Elmhurst and Hillside. The formation is 20 to 30 feet thick in the outcrop areas, but it is locally missing in the subsurface in the eastern part of the area. The Waukesha formation was not recognized in exploratory holes drilled for the tunnel excavations.

- Joliet formation. The Joliet Dolomite is 40 to 60 feet thick and has 3 distinct units; the Romeo member, Markgraf member, and Brandon Bridge member.

  - Romeo member. The Romeo member is a persistent, fairly uniform, pure, white to cream, very dense, very fine grained dolomite, generally about 14 feet thick, that underlies the Racine Dolomite and grades downward into the Markgraf member. In exposures the Romeo member is locally mottled pink and exhibits poorly developed thick bedding. The formation provides a distinctive stratigraphic marker which is especially useful in determining possible displacement along faults.

    The Romeo, found in tunnels and drill holes, is uniformly fresh rock. Core recovery is commonly 100 percent and RQD is usually 95 percent or higher.

  - Markgraf member. The Markgraf member is a widespread, distinctively light bluish gray dolomitic unit that underlies the Romeo member. The upper contact is defined as the uppermost cluster of shale partings. The minimum thickness is 9 feet; the maximum is 51 feet; and the average is 23 feet.

    The member consists of an upper zone which is fine-grained and dense and which contains a few thin clustered shale partings and soft, porous chert nodules; a middle argillaceous zone; and a silty lower zone in which closely spaced dolomitic shale laminae become increasingly common. The shale partings do not appear to slake badly. In addition to interlocking dolomite grains averaging 0.04 mm in diameter, petrographic analyses report thin, opague streaks or organic matter.

    The Markgraf, found in tunnels and drill holes, is uniformly fresh rock. Core recovery is commonly 100 percent and RQD is usually 95 percent or higher.

- Brandon bridge member. The Brandon Bridge member is absent in most of the Chicago area.

- Alexandrian series. The Alexandrian Series is composed of two formations; the Kankakee and the Edgewood.

  - Kankakee formation. The general characteristic feature of the Kankakee formation is wavy beds of fine-to-medium grained, greenish-gray, locally pinkish, dolomite layers, one to three inches thick. The bedding is often separated by numerous thin wavy partings of green shale. The upper contact is marked by a thin lamina of bright green shale which occurs on a distinctive smooth, but deeply pitted, surface.

    Four zones of slightly differing lithologies have been identified within the Kankakee formation in the literature. These zones have been named the Plaines, Troutman, Offerman, and Drummond members of the Kankakee formation.

    The uppermost zone, the Plaines member, is a distinctive, porous, pure, white dolomite unit. Its thickness is two to three feet. The thickest zone of the Kankakee, underlying the Plaines member and comprising over half of the formation, is the Troutman member. Its description fits the generalized description of the Kankakee, greenish to pinkish gray dolomite containing wavy green shale partings. A few sporadic chert nodules occur in this unit.

    A thin zone, only a few feet thick, of slightly argillaceous, thin bedded dolomite comprises the Offerman member. The basal unit, the Drummond member, is a thicker-bedded, fossiliferous dolomite which contains thin shale partings, scattered glauconite, and rounded quartz grains.

    The shale partings of the Plaines and Drummond members, usually one-eighth inch thick (but up to one-half inch thick) and one inch apart have shown signs of deterioration in cores exposed to the atmosphere. All laboratory tests were performed on freshly waxed samples so that shale deterioration prior to testing was prevented.

The Kankakee dolomite, as found throughout the Chicago area, usually has a thickness of 35 to 45 feet, but was found to range in drill holes from 10 to 79 feet. The contact with the underlying Edgewood formation is conformable. The Kankakee, found in drill holes, is uniformly fresh rock. Core recovery is generally in the 95 to 100 percent range and RQD is commonly above 95 percent. The RQD values are slightly more variable than in the overlying units, however, and scattered values in the 53 to 75 percent range are reported.

- Edgewood formation. The Edgewood formation is the oldest unit of the Silurian system. Its thicknes range varies widely because it was deposited on the underlying erosional surface developed on the top of the Maquoketa group (generally the Brainard Shale). The thickness ranges from about 10 feet, where the Brainard was little eroded, to over 100 feet, where the Brainard was deeply eroded.

The Edgewood is a light gray to gray and fine-to-medium grained dolomite slightly argillaceous in the upper 30 feet but very cherty. Its upper contact is marked by the first chert nodule below the top of the Kankakee formation. The chert occurs in the form of interbeds and nodules to 0.3 foot thick at an average spacing of one foot. The chert is white, soft, and porous.

The lower portion of the Edgewood may be divided into an argillaceous, slightly cherty colomite unit underlain by a very argillaceous, noncherty dolomite unit. The chert nodules decrease in frequency and size with depth, but become harder. Conversely, the argillaceous content and frequency and thickness of shale and dolomite shale partings increase with depth through the formation. The base is marked by laminated, crinkled beds. Where the Edgewood formation is very thick the lowest beds consist of dolomitic shale with a basal layer of dolomitic siltstone, and containing brownish-black pebbles in a dolomitic shale matrix.

It has been proposed that the formation be divided into two parts, each of which is to be elevated to the rank of formation. The upper, very cherty unit, described in the first paragraphs of the Edgewood description, would be called the Elwood formation, and the lower argillaceous, slightly cherty unit, described in the second paragraph, would be called the Wilhelmi formation. The Wilhelmi formation would then be divided into two members; the Birds member, an argillaceous and slightly cherty dolomite overly the non-cherty Schweizer member, a very argillaceous dolomite to dolomitic shale.

The Edgewood found in drill holes is uniformly fresh rock. Core recovery is generally in the 95 to 100 percent range and RQD is commonly above 95 percent. A few RQDs in the 80 to 90 percent range and an occasional RQD of 59 to 80 percent is reported.

- Ordovician. The Ordovician is subdivided into 3 series; the Canadian, Champlainian, and the Cincinnatian. These series, in turn, are subdivided into groups. The Middle Ordovician Champlainian series has three groups; the Galena, Platteville, and Ancelli; while the Canadian series has one group, the Prairie du Chien; and the upper Ordovician Cincinnatian has one group, the Maquoketa. Only the Maquoketa group falls within the range of the drop shafts and tunnels.

- Cincinnatian. The upper Ordovician is predominately gray and green shale, but includes brown, red, and black shales. It has a persistent limestone formation in the middle and hematite oolites at the top.

- Maquoketa group. The Maquoketa group consists of four formations; the Neda formation, Brainard shale, Fort Atkinson, and the Scales Shale.

  - Neda formation. The Neda formation, the uppermost formation of the Maquoketa group is an iron-oxide-bearing, brick red shale, zero to 15 feet thick (5 feet average) of restricted distribution. It is found only where the Brainard formation is very thick. Much of the Neda was probably removed by pre-Edgewood erosion.

Characteristics of the Neda formation, other than color, are similar to those of the underlying Brainard Shale.

- Brainard formation. The Brainard formation is a dark greenish gray, thin bedded, fossiliferous, silty claystone to shale with interbedded dolomite. The upper contact is sharp.

As a result of pre-Edgewood erosion, as described previously, the Brainard Shale varies in thickness from one to 136 feet depending on the configuration of the Brainard-Edgewood unconformity. In many holes the formation is less than 50 feet thick. It is locally absent.

In general, the Brainard is lithologically uniform. Interbedded dolomite occurs as 3-inch-thick layers spaced about one foot apart; generally more numerous where the Brainard is thin. Petrographic analyses report 90 percent clay and 10 percent scattered dolomite grains 0.01 to 0.02 mm in size, with scattered clusters of pyrite. X-ray analyses indicate 3 parts illite clay to one part chlorite intermixed with dolomite.

The Brainard, found in drill holes, is uniformly fresh rock. Core recovery is generally above 90 percent and RQD is commonly over 80 percent.

- Fort Atkinson formation. The Fort Atkinson varies considerably in composition. It consists of gray, fossiliferous, shaly limestone; tan and pink, crinoidal coarsely crystalline limestone overlying fine grained dolomite; and mostly fine grained limestone with shale partings. In borings in the Chicago area, it is a very hard, brownish-gray medium grained, fossiliferous dolomite with some shale beds. It varies in thickness from 6 feet to 40 feet, averaging 17 feet

Petrographic analysis reported granular interlocking grains of dolomite, 0.02 to 0.4 mm in size elongated paralled to bedding, and fossil fragments.

- Scales Shale. The Scales Shale is largely gray shale, but the lower part is locally dark brown to nearly black in the southern part of the area. Much of the shale is dolomite. Thin beds with small black phosphatic nodules and small pyrite fossils occur near the base and locally near the top. As observed in borings, this formation is a soft, dark gray, very uniform thin-bedded shale, averaging 100 feet in thickness.

Petrographic and x-ray analyses show 5 to 10 percent scattered dolomite grains in a matrix of clay that is three parts illite to one part chlorite. Disseminated pyrite is also present.

APPENDIX C

DESCRIPTION OF FAULTS LOCATED IN THE CHICAGO AREA

APPENDIX C

DESCRIPTION OF FAULTS LOCATED IN THE CHICAGO AREA

1.1 FAULT CHARACTERISTICS

By definition, a fault is a fracture along which displacement has occurred. In the three recently completed tunnels, much of the fault displacement was seen to be horizontal, or strike-slip, as shown by slikensided fault surface (scratched surfaces showing the direction of movement). As there is no vertical movement along a strike-slip fault and as joint and fault fillings are very similar, it is likely that some faults were mapped as joints.

As bedding is horizontal or very gently inclined, and as the fault movement appears to have been largely strike-slip (horizontal), substantial horizontal movement is required to produce a vertical displacement of as little as one foot. Since the identification of faults in flat-lying strata, by means of seismic surveys or core drilling, depends primarily on observations of vertical displacement of beds, strike-slip faulting, prevalent in the Chicago area, would be expected to be undetected by these methods, unless core drilling disclosed a zone of disturbed rock attributable to faulting.

The fault surfaces are generally slickensided and often have fluted or washboard structure. All striations noted were horizontal or near-horizontal. The faults are invariably filled with grey, black or green clay and lesser amounts of breccia. Fault widths are largely in the range of a fraction of an inch to 2 or 3 inches, however, a few of the faults obtain locally a width of 6 inches, and a maximum width of 12 inches was noted on a fault in the Southwest Tunnel. Apparent stratigraphic offsets vary normally from a fraction of an inch to 6 inches, and reach a maximum of 8 inches.

2.1 SURVEY RESULTS

Most of the fault dips in the Chicago area were found to be vertical or near-vertical. A few of them varied from the vertical by as much as 15 degrees. The seismic survey delineated 30 faults in the area surveyed, omitting the Des Plaines disturbance and its boundary faults.

In the area north of Irving Park Road, along the North Shore Channel, and along the North Branch of the Chicago River, only one seismically mapped fault was actually crossed by the line of explorations. Displacement at this fault was indicated to be only about 10 feet. The eastern end of another fault came within 1,000 feet of the North Branch section. Although slight undulations were interpreted from the core borings in the beds in the areas of these two faults, they are no greater than in other areas along the North Branch where no faults were mapped. Furthermore, the rock in the holes drilled to explore these faults revealed no disturbance. Although no fault at this location has been shown, a fault having predominantly horizontal movement and little vertical displacement cannot be excluded.

One fault was mapped by the seismic survey as crossing the Chicago River between Polk and Harrison Streets. A group of holes were drilled to confirm the existence, nature, and extent of any fault at this location. The drilling confirmed the fault, and indicates a displacement of 25 feet on the top of the Galena between Taylor Street and Roosevelt Road. The southern side was found to be lower. It appears now that the zone of possible fault disturbance is limited in extent.

There is a disturbed and faulted zone in the area between Chicago Avenue and Lake Street. No fault was mapped in this area by the seismic survey. Nevertheless, drilling in this area encountered extensive lengths of hole in rock that was closely fractured, fragmental, and gouged. Joints showing slickensides were also common. In one drill hole the Maquoketa shales were sheared and showed signs of remolding.

To further delineate this zone of disturbance, two additional holes were drilled. One drill hole contained considerable sections of fragmental core and had a Galena top 30 feet higher than that in the hole, 1,300 feet to the south. A core loss, perhaps due to poor quality rock, of 13 feet was reported in the latter boring. The displacement of beds in this area would seem to indicate a fault or fault zone between these holes. It is possible that an additional fault of lesser displacement could occur between Randolph and Ohio Streets. It is in this area where a proposed short feeder tunnel intersects the main tunnel.

Additional evidence of faulting in this area is found in reports of the Des Plaines Street and Chicago Avenue

Tunnels. The former, excavated in 1938, encountered a zone with clay slips or faults carrying large quantities of water. The main fault was reported as nearly vertical with a northeast-southwest orientation. This broken zone is located south of Erie Street at the tunnel elevation of approximately -160 CCD (Chicago City Datum). Clay slips which were very wet and which required timbering were also described in the Des Plaines Street Tunnel report.

Seepage in the Chicago Avenue Tunnel, driven in 1930, was reported to have increased greatly when the tunnel reached distances of 600 feet east and west of a shaft at the Chicago River. At that point two 300 gpm pumps were required to control the leakage. One pump was operated 16 hours per day, six days per week and the other pumped about 24 hours per week.

In another reach of the Chicago Avenue Tunnel, numerous faults were mapped and were reported to form a graben 820 feet wide, extending east and west of a shaft at the Lake Shore. The faults in this area are nearly vertical and contain clay filled, brecciated zones up to three feet wide. Displacements greater than 13 feet are reported in six faults, two of which had displacements of 36 and 48 feet. These faults were very troublesome to tunneling, because of large water inflows and a need for support of the roof rocks. Joints showing solutioning and filled with clay pockets up to 100 feet wide were reported. Some of these required timbering and one necessitated the use of concrete lining.

The faulting, close jointing, and disturbance observed in the 1971 exploration program, in the Des Plaines Street Tunnel, and in the two reaches of the Chicago Avenue Tunnel are very likely interrelated. A more detailed evaluation of the areal and vertical extent of the zone, the magnitude of the displacement, brecciation, leakage, and solution phenomena will require further drilling in the design phase.

Seven faults crossing the line along the tunnel, along the Des Plaines River, and south of the Des Plaines complex were mapped by the seismic survey. Subsequent drilling has not confirmed the presence of three of these faults.

Of the remaining four faults, three have been substantiated by the 1971 explorations. These have apparent displacements of 25 feet, 50 feet, and 10 feet. Displacement of the fourth fault was measured at 20 feet in the drilling. However, no fault of such large displacement was observed in the Southwest Intercepting Sewer 13A Tunnel, which crosses this same seismically mapped fault.

Rock in the vicinity of the 25 foot and 10 foot faults displayed unusually severe fracturing or gouge. In particular, one boring north of the 25 foot fault followed for 20 feet a joint filled with clay and broken pieces of dolomite. In some cases, the joint filling was wider than the core diameter. A core loss of eight feet was also reported in this hole, and slickensided joint surfaces were found in another drill hole south of the fault. A core sample from a boring north of 10 foot fault contained gouged sections and the Platteville section was closely fractured.

3.1 FAULTS AFFECTING TARP

Two feeder tunnels, which will intersect the proposed Tunnel from the west, may cut by a 50 foot fault, based on the seismic survey. This fault may cross the more northern of the feeder tunnels and a 20 foot fault may cross the southern tunnel.

Data mapped by the seismic survey on the geologic structure and on faulting in the Lake Calumet area has not been substantiated by drilling. In this area ten faults were mapped by the seismic method. All of these are shown in the area east of the Calumet Tunnel. No faults were mapped along the tunnel alignment from the Calumet Tunnel northwest to the Chicago Sanitary and Ship Canal.

The proposed tunnel may cross one fault having a displacement of 20 to 30 feet, and another fault with a displacement of about 30 feet. The tunnel is close a fault of unknown displacement near its intersection with the 30 foot fault.

The Calumet River branch of the tunnel may cross five east-west trending faults. These faults, located from south to north, have a displacement of about 20 to 25 feet. The short feeder tunnel which intersects this tunnel segment follows or closely parallels a 20-to-25 foot fault throughout the length of the tunnel.

The Little Calumet River branch of the system parallels one fault for a considerable distance and may cross another fault as well, depending on the exact location of the tunnel. The displacement on the former fault ranges from a few feet to about 30 feet and the latter is about 20 feet.

APPENDIX D

AIR QUALITY STANDARDS

APPENDIX D

AIR QUALITY STANDARDS

Air quality is measured in terms of time-averaged pollutant concentrations in the air, usually at ground level, where people and property are most often exposed to the pollutants. For various substances which have been identified as air pollutants, air quality standards for them have been set at the Federal and state levels.

The air quality standards can be divided into the following classes:

- Ambient air quality standards
- Nondegradation criteria
- Standards for hazardous air pollutants
- Occupational Safety and Health Act regulations.

The first two classes of standards apply to pollutant concentrations in the outdoor air, whereas the third, standards for hazardous air pollutants, applies to the emission of such pollutants. These standards are discussed below. The fourth class, the Occupational Safety and Health Act regulations, apply to pollutant concentrations inside industrial plants and other job areas where workers are likely to be exposed to pollutants. Therefore, they are not discussed here.

1.1 AMBIENT AIR QUALITY STANDARDS

Pursuant to the Clean Air Act of 1970, the U.S. EPA has established national ambient air quality standards for six pollutants: sulfur dioxide, particulate matter, carbon monoxide, hydrocarbons, nitrogen dioxide, and photochemical oxidants. These standards are shown in Table D-1. They consist of both primary standards, which are intended to protect public health, and secondary standards, which are intended to protect public welfare, including protection against damage to property and vegetation, and aesthetic damage.

The State of Illinois has also established ambient air quality standards. The state particulate standards are the same as the Federal standards. However, for carbon monoxide, oxidants, hydrocarbons, and nitrogen dioxide, the state has only one set of standards equivalent to the Federal secondary standards.

Table D-1
National Ambient Air Quality Standards

Pollutant	Primary Standards	Secondary Standards
Sulfur Dioxide	80 μgm/m^3 (aam) 0.03 ppm 365 μgm/m^3 0.14 ppm (24 hr.)[1]	1300 μgm/m^3 0.50 ppm (3 hr.)[1]
Total Suspended Particulate	75 μgm/m^3 (agm) 260 μgm/m^3 (24 hr.)[1]	60 μgm/m^3 (agm) 150 μgm/m^3 (24 hr.)[1]
Carbon Monoxide	10 mgm/m^3 (24 hr.)[1] 9 ppm 40 mgm/m^3 (1 hr.)[1] 35 ppm	10 mgm/m^3 (8 hr.)[1] 9 ppm 40 mgm/m^3 (1 hr.)[1] 35 ppm
Photochemical Oxidants	160 μgm/m^3 (1 hr.)[1] 0.08 ppm	160 μgm/m^3 (1 hr.)[1] 0.08 ppm
Non-methane Hydrocarbons	160 μgm/m^3 [1,2] 0.24 ppm	160 μgm/m^3 (3 hr.)[1,2] 0.24 ppm
Nitrogen Dioxide	100 μgm/m^3 (aam) 0.05 ppm	100 μgm/m^3 (aam) 0.05 ppm

1 - Not to exceed more than once a year
2 - 6 a.m. to 9 a.m.
aam - annual arithmetic mean
agm - annual geometric mean
μgm - microgram
mgm - milligram
ppm - parts per million
m^3 - cubic meter

2.1 NONDEGRADATION CRITERIA

The intent of the nondegradation criteria, established in December 1974, is to prevent significant deterioration of air quality in areas with currently clean air. These criteria apply to increments in the existing ambient concentration of particulate matter and of sulfur dioxide.

Three classes with different allowable increments in the above concentrations have been established: Class I represents the cleanest areas in which a small increment may cause significant deterioration, Class II represents the areas in which an increment associated with moderate urban growth may not significantly affect the air quality, and Class III represents the highly developed urban areas in which degradation of air quality up to the national ambient air quality standards may not be considered significant. Table D-2 summarizes the nondegradation criteria.

Initially, all areas in the U.S. were designated as Class II, but the states have the option of reclassifying any area to suit local community needs. Illinois has not reclassified any areas in the state.

3.1 HAZARDOUS AIR POLLUTANTS

Those air pollutants with no applicable ambient air quality standards are included in the hazardous air pollutant category. The EPA has also established emission standards for such pollutants. At present, asbestos, beryllium, and mercury are designated as hazardous air pollutants. The EPA has the authority to include other substances in this category if they are found to pose a threat to public health and welfare.

Table D-2
Significant Deterioration Criteria

Pollutant	Allowable Increments	
	Class I $\mu g/m^3$	Class II $\mu g/m^3$
Particulate matter		
Annual geometric mean	5	10
24-hour maximum	10	30
Sulfur dioxide		
Annual arithmetic mean	2	15
24-hour maximum	5	100
3-hour maximum	25	700

For Class III, the above concentrations could increase until the air quality degrades up to the national ambient standards.

APPENDIX E

NOISE: UNITS AND STANDARDS

APPENDIX E

NOISE: UNITS AND STANDARDS

1.1 NOISE UNITS

Noise is often defined as unwanted sound. A complete noise description includes magnitude, frequency distribution, direction of propagation, variation with time, and operating conditions of the noise generator.

Urban noise is a mixture of sounds produced by a variety of sources including vehicles, industrial plants, construction activity, sirens, appliances, power equipment, and conversation. Although noise is generally uniform in all directions, it varies in magnitude and frequency with time. It is possible to describe urban noise in terms of its magnitude for each frequency and at each instant. However, such description would be too voluminous and difficult to compare with other noise. Various noise units have been developed to describe urban noise in terms of a single number, which can account for its magnitude, frequency, and duration. This section describes the basic unit of noise: the decibel (dB), the A-weighted decibel (dBA), and the day-night sound level (L_{dn}).

(1) Decibel (dB)

The magnitude of noise is generally measured by its sound pressure level referred to a standard pressure level. The reference pressure level is generally taken to be 0.0002 microbar, which is the threshold of audible sound. Because of the vast range of sound pressure levels that can be heard by the human ear, noise is expressed in terms of a logarithm of the ratio of measured to standard sound pressure levels. The resulting unit is termed as decibel (dB). Thus, dB = $20 \log_{10} P/P^*$, where P = measured sound pressure; P* = reference sound pressure, generally taken to be 0.0002 microbar (2×10^{-5} Newton/m^2).

(2) A-Weighted Sound Pressure Level (dBA)

Human response to noise varies with noise frequency. The response is approximately constant for frequencies between 500 and 10,000 Hz, but drops off sharply below 100 Hz and above 20,000 Hz. To account for this variation in human noise response, the measured noise signal is weighted, giving less importance to the low and high frequencies and more importance to the midrange frequencies. There are several internationally approved noise weighting scales designed for different purposes. For community noise, the A-scale is used, and the resulting unit is called dBA.

(3) Day-Night Sound Level (L_{dn})

Many attempts have been made to describe the time-varying noise in terms of a single index. The U.S. EPA has recommended the day-night sound level (L_{dn}) as an index for community noise. It is based on the Equivalent Sound Level (L_{eq}). The L_{eq} is defined as "the constant sound level which if lasted for the actual total duration of the noise signal, would yield the same value of energy average as the actual sound level over the total duration of the noise."[1]

The L_{dn} represents the average L_{eq} over 24 hours, with a 10-dB nighttime weighting. Mathematically, L_{dn} is expressed as follows:[2]

$$L_{dn} = 10 \text{ Log}_{10} \left(\frac{15}{24} \times 10^{L_d/10} + \frac{9}{24} \times 10^{(L_n + 10)/10}\right)$$

where L_{dn} = weighted noise level for 24-hour period
L_d = average of hourly L_{eq}'s between 7 a.m. and 10 p.m.
L_n = average of hourly L_{eq}'s between 10 p.m. and 7 a.m.

2.1 NOISE STANDARDS

Various Federal, state, and local governmental agencies have established noise control regulations and guidelines.

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[1] Bolt, Berack & Newman, Inc., Noise in the Urban Environment, for city of Chicago, Department of Environmental Control, November 1970.

[2] Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety, U.S. Environmental Protection Agency, Report 550/9-74-004, March 1974.

At the Federal level, the Department of Housing and Urban Development (HUD), the Federal Highway Administration (FHWA), the Occupational Safety and Health Administration (OSHA),. and the EPA have noise standards or guidelines in effect. The State of Illinois and the city of Chicago also have established noise control regulations. These standards and guidelines are discussed below.

(1) EPA Guidelines

In response to the Noise Control Act of 1972, the EPA identified long-term noise levels considered necessary to protect the public health and welfare with an adequate margin of safety. These identified noise levels do not represent EPA standards, but are considered necessary by the EPA both to protect the most sensitive segment of public from any measurable hearing loss and to minimize feelings of annoyance, both with an adequate margin of safety. The EPA findings are given in terms of L_{eq} over 24 hours; Table E-1 shows the EPA findings in terms of L_{dn}. The conversion factor is shown at the bottom of the table.

(2) HUD Noise Criteria

The Noise Abatement and Control Standards established by HUD are intended to remove uncontrollable noise sources from residential and other noise-sensitive areas and to prohibit HUD support for new construction on sites having unacceptable noise exposure. The HUD noise criteria for funding new residential construction are given in terms of Noise Exposure Forecast (NEF) values. The NEF values can be converted into L_{dn} by using the equation, L_{dn} = NWF + 35 dB. The criteria in terms of L_{dn} are as follows:

Noise Levels, L_{dn}	HUD Policy
Less than 65 dB	Acceptable
65 to 75 dB	Discretionary
More than 75 dB	Unacceptable

(3) FHWA Noise Standards

The FHWA of the Department of Transportation has established noise standards and procedures to be used

Table E-1

Summary of Noise Levels Identified as Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety[1]

Effect	Level	Area
Hearing Loss	$L_{dn} \leq 74$ dB	All areas
Outdoor activity interference and annoyance	$L_{dn} \leq 55$ dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{dn} \leq 59$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas.
	$L_{dn} \leq 49$ dB	Other indoor areas with human activities such as schools, etc.

NOTE: All L_{eq} values converted to L_{dn} for ease of comparison (L_{dn} equals L_{eq} (24) + 4 dB).

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[1] U.S. EPA, March 1974.

in highway planning and design. These standards have been established in terms of the L_{10} values, which represent the noise level in dBA exceeded ten percent of the time. The FHWA standards are summarized in able E-2.

Table E-2
FHWA Noise Standards

Land Use Type	Design Noise Level, L_{10}
Parks and areas requiring special qualities of serenity and quiet	60 dBA (Exterior)
Residential, business and commercial	70 dBA (Exterior) 55 dBA (Interior)
Uses other than those mentioned above	75 dBA (Exterior)

(4) OSHA Noise Regulations

OSHA, of the Department of Labor, has established noise standards to protect the health and safety of industrial workers. According to OSHA standards, a worker may not be exposed to noise levels greater than 90 dBA for eight hours per day. For shorter durations, exposure to higher noise levels is allowed as follows:

Duration Per Day (Hours)	Sound Level (dBA)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

The EPA has recommended a limit of 85 dBA for eight-hour exposure with higher limits for shorter durations.

(5) State of Illinois Noise Standards

The Illinois noise standards apply to noise levels measured beyond 25 feet from a property-line noise-source. The standards vary with types of land use, which are divided into three classes: A, B, and C. The standards depend not only on the class in which the noise level is measured, but also on the class in which the noise source is located. For example, a noise source located in Class C may emit higher noise to an adjacent Class B area than Class A area.

The Illinois noise standards are given in terms of octave band sound pressure levels and can be found in the Environment Reporter.[1]

(6) City of Chicago Noise Standards[2]

The city of Chicago promulgated a comprehensive noise control ordinance in July 1971. This ordinance established limits on noise from motor vehicles, construction equipment, power tools and equipment, and recreational vehicles sold, as well as operated in the city of Chicago. Standards for noise from buildings were also established.

The maximum allowable noise levels measured at 50 feet from new construction vehicles and equipment sold in Chicago are shown in the following table.

	Noise Limit (dBA)	
Manufacture Date	Vehicles (8,000 lbs. or more gross weight)	Construction Equipment*
After Jan. 1, 1968	88	N/A
After Jan. 1, 1972	88	86
After Jan. 1, 1973	86	84
After Jan. 1, 1975	84	80
After Jan. 1, 1980	75	75

* Does not include pile drivers.

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[1] Illinois Noise Pollution Regulations, Environment Reporter, Noise Control Regulations, October 1975, p. 81:4921.

[2] City of Chicago Noise Ordinance, Chapter 17 of the Municipal Code of Chicago, as amended in 1971.

The noise responsibility does not end with manufacturers. The user must maintain the product so that it will not emit more noise than the manufacturer intended. For vehicles with gross weight 8,000 lbs. or more, the following noise restrictions apply during operation:

Date	Noise Limit (dBA) at 50 Feet For Posted Speed Limits	
	35 mph or Less	Over 35 mph
Before Jan. 1, 1973	88	90
After Jan. 1, 1973	86	90

The noise ordinance also prohibits use of noisy construction equipment in residential areas between 9:30 p.m. and 8:30 a.m. except for work on public improvements and work for public service utilities.

In the case of noise from buildings, the restrictions apply to noise levels measured at the property line or at the boundary of zoning district as follows:

Type of Land Use	Location of Noise Measured	Noise Limit (dBA)
Residential	Property Line	55
Commercial	Property Line	62
Industrial	Zoning District Boundary	58 to 66

APPENDIX F

SOCIOECONOMIC DATA BY COMMUNITY FOR THE MAINSTREAM, CALUMET, AND DES PLAINES TUNNEL SYSTEMS

APPENDIX F

SOCIOECONOMIC DATA BY COMMUNITY FOR THE MAINSTREAM, CALUMET, AND DES PLAINES TUNNEL SYSTEMS

SOCIOECONOMIC DATA - MAINSTREAM AREA COMMUNITIES[1]

Community	1970 Population	Percent Change From 1960	Median Family Income-1970
Bedford Park	583	-20.9	-
Bellwood	22,096	6.6	13,008
Bensenville	12,956	41.7	13,394
Berkeley	6,152	6.2	13,708
Berwyn	52,502	-3.2	11,836
Bridgeview	12,522	70.7	11,910
Broadview	9,623	12.1	12,553
Brookfield	20,284	-0.7	12,993
Burr Ridge	1,637	447.5	-
Chicago	3,369,357	-5.1	10,242
Cicero	67,058	-3.0	11,265
Countryside	2,864	-	12,976
Des Plaines	57,239	64.1	14,056
Elmwood Park	26,160	9.6	13,028
Evanston	80,113	1.0	13,932
Forest Park	15,472	7.1	11,941
Forest View	927	-11.0	-
Franklin Park	20,348	11.1	12,833
Glencoe	10,675	1.9	29,565
Glenview	24,880	37.2	19,137
Golf	474	15.9	-
Harwood Heights	9,060	59.3	13,208
Hillside	8,888	14.0	14,079
Hinsdale	215,918	23.8	19,185
Hodgkins	2,270	101.6	-
Hometown	6,729	-10.0	11,118

SOCIOECONOMIC DATA - MAINSTREAM AREA COMMUNITIES[1]
Continued

Community	1970 Population	Percent Change From 1960	Median Family Income-1970
Indian Head Park	473	22.9	-
Justice	9,473	238.0	11,745
Kenilworth	2,980	0.7	34,573
LaGrange	17,814	16.5	16,552
LaGrange Park	15,459	12.1	15,237
Lincolnwood	12,929	10.1	21,365
Lyons	11,124	12.0	11,998
Maywood	29,109	6.5	11,573
McCook	333	-24.5	-
Melrose Park	22,716	1.9	12,121
Morton Grove	26,369	38.4	16,488
Niles	31,432	54.1	14,159
Norridge	17,020	20.8	13,996
Northbrook	27,297	134.6	19,994
Northfield	5,010	25.1	21,268
Northlake	14,212	15.4	12,561
North Riverside	8,097	1.4	13,219
Oak Park	62,511	2.3	12,949
Park Ridge	42,614	30.5	17,472
River Forest	13,402	5.6	21,236
River Grove	11,465	35.5	12,480
Riverside	10,432	7.0	16,389
Rosemont	4,360	345.8	12,824
Schiller Park	12,712	123.5	12,695
Stickney	6,601	5.8	12,060
Stone Park	4,429	45.8	12,013
Summit	11,569	11.5	10,281
Westchester	20,033	10.7	15,812
Western Springs	13,029	20.2	19,502

SOCIOECONOMIC DATA - MAINSTREAM AREA COMMUNITIES[1]
Continued

Community	1970 Population	Percent Change From 1960	Median Family Income-1970
Willow Springs	3,318	41.3	12,713
Wilmette	32,134	13.7	21,809
Winnetka	13,998	4.7	28,782
Skokie	68,322	15.1	16,423

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[1] Suburban Fact Book - 1973, Northeastern Illinois Planning Commission.

SOCIOECONOMIC DATA - CALUMET AREA COMMUNITIES[1]

Community	1970 Population	Percent Change From 1960	Median Family Income-1970
Alsip	11,141	195.5	12,687
Blue Island	22,958	17.0	11,470
Burnham	3,634	46.7	11,262
Calumet City	33,107	32.4	11,823
Calumet Park	10,069	19.2	12,546
Chicago	3,369,357	-5.1	10,242
Dixmoor	4,735	53.9	10,565
Dolton	25,937	38.4	13,282
Evergreen Park	25,921	7.2	13,903
Harvey	34,636	19.1	11,035
Lansing	25,805	42.6	13,069
Markham	15,987	36.6	12,045
Oak Lawn	60,305	119.5	13,824
Phoenix	3,596	-14.4	9,800
Posen	5,498	21.7	11,866
Riverdale	15,806	31.6	12,520
Robbins	9,641	28.4	8,192
South Holland	23,931	129.8	14,495

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[1] Suburban Fact Book - 1973, Northeastern Illinois Planning Commission.

SOCIOECONOMIC DATA - DES PLAINES AREA COMMUNITIES[1]

Community	1970 Population	Percent Change From 1960	Median Family Income-1970
Broadview	9,623	12.1	12,553
Brookfield	20,284	-0.7	12,993
Des Plaines	57,239	64.1	14,056
Elmwood Park	26,160	9.6	13,028
Forest Park	15,472	7.1	11,941
Franklin Park	20,348	11.1	12,833
LaGrange	17,814	16.5	16,552
LaGrange Park	15,459	12.1	15,237
Lyons	11,124	12.0	11,998
Maywood	29,019	6.5	11,573
McCook	333	-24.5	-
Melrose Park	22,716	1.9	12,121
North Riverside	8,097	1.4	13,219
Park Ridge	42,614	30.5	13,472
River Forest	13,402	5.6	21,236
River Grove	11,465	35.5	12,480
Riverside	10,432	7.0	16,389
Rosemont	4,825	345.8	12,824
Schiller Park	12,712	123.5	12,695
Western Springs	13,029	20.2	19,502

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[1] Suburban Fact Book - 1973, Northeastern Illinois Planning Commission.

APPENDIX G

CHRONOLOGY OF IMPORTANT EVENTS - 1954 THROUGH 1975

APPENDIX G

CHRONOLOGY OF IMPORTANT EVENTS - 1954 THROUGH 1975

Year	Month	Description of Events	Reports Issued
1954	-	Leffler Plan proposed (Alternative K*).	-
1958	August	Meissner Plan proposed (Alternative L).	Meissner, John F., "Flood Control - A Report for the Metropolitan Sanitary District," Engineers, Inc.
1959	February	Ramey-Williams Channel Improvement Plan proposed (Alternative M).	Ramey, H.P., "Floods in the Chicago Area," A Report for the MSDGC.
1960	March	-	McCarthy, R.L., "Supplement to Proposed Flood Control Project for the MSDGC."
1961	-	-	State of Illinois, "Report on Plan for Flood Control and Drainage Development, Des Plaines River, Cook, Lake and DuPage Counties," Dept. of Public Works and Buildings.
			______________, ______________ Appendix G.
1964	-	Original Deep Tunnel Plan with Mined and Surface Storage in the Calumet Area proposed (Alternative A).	-
		Metropolitan Sanitary District of Greater Chicago Flood Control Studies resulted in proposed plan (Alternative P).	-

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* Flood Control Cordinating Committee designations.

Year	Month	Description of Events	Reports Issued
1965	-	Flood Control Coordinating Committee (FCCC) formed and members appointed by Governor of Illinois.	-
1966	-	Commenced investigations on mining machines (MSDGC).	-
	May	-	Harza Engineering Co. and Bauer Engineering, Inc., "A Deep Tunnel Plan for the Chicagoland Area," A Report for the MSDGC.
	October	-	Harza Engineering Co. "Appraisal Report on Storm Drainage by Alternative Open-cut and Tunnel Sewers for the Eastwood Wilson Auxiliary Outlet Sewer System," report for Department of Public Works.
1967	January	Original Chicago Underflow Plan for Flood and Pollution Control proposed (city of Chicago).	City of Chicago, "The Chicago Underflow Plan for Flood and Pollution Control," Dept. of Public Works, Bureau of Engineering.
	November	The FCCC appointed members for a technical advisory committee (TAC).	-
		Lawrence Avenue underflow sewer system construction commenced (city of Chicago).	-
		MSDGC initiated feasibility studies on Chicago tunnel plans.	-
		Drilling and testing of deep aquifer test and specific capacity wells commenced (MSDGC).	-

Year	Month	Description of Events	Reports Issued
1967	November (Continued)	Seismic survey of 5 locations commenced to determine efficacy of vibrosis (MSDGC). Drilling and testing of 36 shallow and deep holes commenced to determine general subsurface conditions (MSDGC).	-
1968	February	-	Harza Engineering Co. and Bauer Engineering, Inc., "Pollution and Flood Control: A Program for Chicagoland," a report for the MSDGC.
1968	May	Seismic survey completed	Seismograph Service Corp., "Reports on a Vibrosis Survey, Chicagoland Deep Tunnel Plan for Pollution and Flood Control, Phases I-III Mobilization and Reconnaissance," for the MSDGC.
	May	-	Harza Engineering Co., and Bauer Engineering, Inc., "Chicagoland Deep Tunnel System for Pollution and Flood Control - First Construction Zone Definite Project Report," for the MSDGC.
	July	-	McCarthy, R.L., "The Metropolitan Sanitary District of Greater Chicago Flood Control Report."

Year	Month	Description of Events	Reports Issued
1968	July (Continued)	-	Harza Engineering Co. and Bauer Engineering, Inc., "Chicagoland Deep Tunnel System for Pollution and Flood Control - First Construction Zone Definite Project Report Appendices."
	September	Composite Plan proposed (Alternative E).	City of Chicago, "Composite Drainage Plan of the Chicago Area," Dept. of Public Works for the TAC.
1968	November	-	Harza Engineering Co. and Bauer Engineering, Inc. "Design, Construction, and Financing Schedule for the Composite Drainage, Flood and Pollution Control Plan for the Combined Sewer Portion of the Metropolitan Sanitary District of Greater Chicago."
	November	State of Illinois, Division of Waterways Plan proposed (Alternative D).	State of Illinois, "Chicago Drainage Plan," Dept. of Public Works and Buildings.
	November	Drilling and testing completed.	Seismograph Service Corp., "Report on Borehole Logging Services, Chicagoland Deep Tunnel System for Pollution and Flood Control," for the MSDGC.
	-	Deep Tunnel Plan with Pumped Storage Power proposed (Alternative A_p).	-
	-	City of Chicago Underflow Plan revised.	-
	-	Sheaffer Plan proposed (Alternative N).	-

Year	Month	Description of Events	Reports Issued
1968	November (Continued)	Deep Tunnel Plan with Mined and Surface Storage in the Calumet and Stickney Areas proposed (Alternative B).	-
	-	Deep Tunnel Plan (Calumet, Stickney Storage) with Pumped Storage proposed (Alternative B_p.)	-
	-	Deep Tunnel Plan with Mined and Surface Storage in the Calumet, West-Southwest and North-side Sewage Treatment Plant Areas proposed (Alternative C).	-
	-	Deep Tunnel Plan (Storage in Three Locations) with Pumped Storage Power Proposed (Alternative C_p).	-
1969	January	Report on effects of deep tunnel storage upon MSDGC's sewage treatment capacity presented to MSDGC.	Bauer Engineering, Inc., "The Effect of Deep Tunnel Storage upon District Sewage Treatment Capacity."
	January	-	Anderson, A.G., and Dahlin, W.Q., "Project Report No. 100 - Supplement No. 1 - Effect of Air and Detergents on Flow Pattern." University of Minnesota.
	February	-	Harza Engineering Co., and Bauer Engineering, Inc., "Report on the Impact of the Deep Tunnel Plan on the Water Resources of Northeast Illinois," for the MSDGC.

Year	Month	Description of Events	Reports Issued
1969	April	-	Koelzer, V.A., Bauer, W.J., and Dalton, F.E., "The Chicago Area Deep Tunnel Project - A Use of the Underground Storage Resource," JWPCF.
	July	-	Bauer Engineering, Inc., "The Role of Storage in Sewage Treatment Plant Design," for the MSDGC.
	September	-	City of Chicago, "Combined Underflow-Storage Plan for Pollution and Flood Control in the Chicago Metropolitan Area," Dept. of Public Works.
1969	October	-	Papadopulos, I.S., Larsen, W.R., and Neil, F.C., "Ground-water Studies - Chicagoland Deep Tunnel System," Ground-water Journal, Vol. 7, No. 5.
1970	May	Chicago Underflow Plan-Lockport proposed (Alternative F).	State of Illinois, city of Chicago, MSDGC, "Underflow Plan for Pollution and Flood Control in the Chicago Metropolitan Area."
	June	Chicago Underflow Plan - Single Quarry proposed (Alternative G).	-
	-	Chicago Underflow Plan - Two Quarries proposed (Alternative H).	-
	-	Chicago Underflow Plan-Three Quarries proposed (Alternative J).	-
	-	Four Storage Plan proposed (Alternative Q).	-

Year	Month	Description of Events	Reports Issued
1970	June (Continued)	Four Storage Plan with Pumped Storage Power proposed (Alternative Q_p).	-
	-	McCook, Calumet, and O'Hare Storage Plan proposed (Alternative R).	-
	-	McCook, Calumet, and O'Hare Storage Plan with Pumped Storage Power proposed (Alternative R_p).	-
	-	Chicago Underflow Plan, McCook and O'Hare Storage proposed (Alternative S).	-
	November	The FCCC reactivated. Work program prepared for development of a flood and pollution control plan. Additional subsurface analysis initiated.	
1971	January	-	DeLeuw, Cather, and Co., "Southwest Side Intercepting Sewer 13A, Report of Tunnel Inspection Performed, November 1970," for the MSDGC.
	February	-	Metcalf & Eddy, "Application of Storm Water Management Model to Selected Chicago Drainage Areas - Phase I," report to City of Chicago, Dept. of Public Works.
	April	Separate System of Sanitary Sewers proposed and evaluated (Alternative T).	City of Chicago, "Estimate of Cost To Provide a Separate System of Sanitary Sewers for the city of Chicago," Dept. of Public Works.

Year	Month	Description of Events	Reports Issued
1971	May	The Technical Advisory Committee re-established.	-
	May	-	MSDGC, "Position Paper concerning Combined Sewer Overflows."
	September	-	Consoer, Townsend and Associates, "Chicagoland Flood and Pollution Control Program Second Interim Report on Treatment to the city of Chicago," a report for the MSDGC.
	September	-	Harza Engineering Co., "Chicagoland Flood Control and Pollution Abatement Program, Interim Report, Geology and Related Studies."
	October	-	Bauer Engineering, Inc., "Final Report - Drop Shaft Investigation for Crosstown Expressway (I-494)."
	October	-	Harza Engineering Co., "Evaluation of Geology and Groundwater Conditions in Lawrence Avenue Tunnel. Calumet Intercepting Sewer 18E, Extension A, Southwest Intercepting Sewer 13A."
1972	-	Tunnel and Reservoir Plan (TARP) proposed.	-
	January	-	MSDGC, "Evaluation of Alternative Systems."
	August	-	MSDGC, "Summary of Technical Reports."

Year	Month	Description of Events	Reports Issued
1972	August	Additional boring tests completed.	Seismograph Service Corp., "Borehole Logging Report for North-Side Rock Tunnel Project."
	October	TARP adopted by FCCC Board.	-
	November	-	DeLeuw, Cather, and Co., "Preliminary Plans for O'Hare Collection Facility," conventional intercepting sewers and TARP.
	December	-	MSDGC, "Technical Reports - "Development of a Flood Control Plan for the Chicagoland Area," Part I - Data Collection; Part II - Computer Simulations Programs; Part III - Treatment; Part IV - Geology and Water Supply; Part V - Alternative Systems; Part VI - Power Generation; Part VII - Benefit-Cost-Financing-Scheduling.
1973	July	Issued "Environmental Assessment" and "Environmental Impact Statement" for TARP for Corps. of Engineers (MSDGC).	-
	-	Preliminary plans and designs for Upper Des Plaines system and O'Hare collection facility prepared (MSDGC).	-
	-	Hydraulic model studies of drop shafts and collecting structures, computer services, refinement of TARP, and preliminary designs of drop shafts initiated (MSDGC).	-

Year	Month	Description of Events	Reports Issued
1973	July (Continued)	Preliminary plans for second phase Calumet tunnels, administration of subsurface exploration, and preparation of geotechnical design report for Calumet system initiated (MSDGC).	-
	-	Preparation of geotechnical design for Mainstream tunnels and two reservoirs initiated (MSDGC).	-
1974	April	Mapping of Mainstream, Calumet and Lower Des Plaines systems commenced (MSDGC).	-
	-	Subsurface exploration of Lower Des Plaines, Calumet, Upper Des Plaines, Mainstream and reservoir systems commenced (MSDGC).	-
	-	Reservoir sites proposed for O'Hare and Calumet areas (MSDGC).	-
	March-September	Drop shaft modeling studies completed and reports issued (University of Minnesota).	Anderson, A.G. and Dahlin, W.Q., Status Reports No. 1 through 6, for the city of Chicago.
1975	January	Drop shaft modeling study completed (University of Minnesota).	Anderson, A.G. and Dahlin, W.Q., "Model Studies of Drop Shafts, Final Report," University of Minnesota, for the city of Chicago.
	July	Hearings conducted by U.S. EPA pertaining to construction grant for tunnels and shafts of Addison to Wilmette and O'Hare systems.	

Year	Month	Description of Events	Reports Issued
1975	September	Hearings conducted by Illinois EPA for design grants of all first phase tunnel systems.	-
	November	Public hearing conducted by U.S. Army Corps of Engineers.	-

APPENDIX H

METROPOLITAN SANITARY DISTRICT
OF GREATER CHICAGO

GENERAL SPECIFICATIONS—CONSTRUCTION CONTRACTS

March 1974

INDEX

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO
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(CONSTRUCTION CONTRACTS)

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THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

GENERAL SPECIFICATIONS

(CONSTRUCTION CONTRACTS)

Definitions.

(1) Whenever the following terms in quotations appear in the contract documents, they shall be interpreted as follows:

"Sanitary District" or "District" – The Metropolitan Sanitary District of Greater Chicago, party of the first part.

"Contractor" spelled with a capital "C" – The Contractor under this contract, party of the second part.

"Chief Engineer" or "Engineer" – The Chief Engineer or Acting Chief Engineer of The Metropolitan Sanitary District of Greater Chicago, or any other Engineer designated by him.

The Purchasing Agent is the duly authorized Officer of the District, carrying out the functions assigned to him by the Purchasing Act (Ill. Rev. Stat. 1963, Ch. 42, Sec. 11.1–11.23) and the Board of Trustees.

"He", "him", "his", "it" or "it's" designating the "Contractor" – The individual, firm or corporation awarded the contract for the work hereunder.

"The work" – The work to be performed hereunder, including all material, labor, tools and all appliances and appurtenances necessary to perform and complete everything specified or implied in the contract or shown on the plans and specifications furnished by the Sanitary District, and the additional plans and information furnished by the Contractor under Section (3), in full compliance with all the terms and conditions hereof.

"Site" – The location described in the Agreement where the work under this contract is to be performed.

"Plans" – The contract plans listed in the Agreement and the additional plans, prints and drawings furnished by the Contractor in accordance with the requirements of Section (3).

"Written Order" – A written order signed by the Chief Engineer of the Sanitary District, a duly appointed Acting Chief Engineer or an Assistant Chief Engineer designated by said Chief Engineer, mailed to the Contractor at the address designated in his proposal or to such other address as he may designate in writing as his official place of business.

"Or equal" or "or equal thereto" – Wherever a particular process, material, device, detail or part is specified herein followed by these words or by similar or equivalent expressions, such words or expressions shall be understood to mean and permit the use of another process, material, device, detail or part that the Engineer shall determine is fully equal in suitability, quality, durability and in all other respects, to the process, material, device, detail or part herein specified for such use and shall approve for such use in the work hereunder.

"Designated", "ordered", "permitted", "approved" – These words or others of similar import, unless specifically modified, shall be taken to mean, designated, ordered, permitted or approved by the Engineer.

Powers of the Engineer.

(2) It is covenanted and agreed that the Chief Engineer and his properly authorized agents shall measure and calculate the quantities and amounts of the several kinds of work performed under this contract and on whose inspection all work shall be accepted or condemned. The Chief Engineer, or other Engineer designated by him, shall have full power to reject or condemn all materials furnished or work performed under this contract, which in his opinion do not conform to the terms and conditions herein expressed.

To prevent all disputes and litigations, it is further agreed by and between the Sanitary District and the Contractor that the Engineer shall in all cases decide every question of an engineering character which may arise relative to the execution of the work under this contract.

on the part of the Contractor, and his decision shall be final and conclusive on both parties hereto; and such decision, in case any question may arise, shall be a condition precedent to the right of the Contractor to receive any money or compensation for anything done or furnished under this contract.

Contractor's Plans, Data and Samples.

(3) Within thirty days after the approval of the bond of the Contractor by the Board of Trustees of the Sanitary District, the Contractor shall submit to the Engineer for approval, plans in duplicate of the equipment, material and apparatus included under this contract and the foundations for same (other than those for which details are given in the plans attached hereto by the Sanitary District), as listed under the Detail Specifications, together with all other information in such detail as may be necessary to permit the Engineer to inform himself whether the same will comply with the specifications, and to determine the character of the various equipment, material and apparatus which the Contractor proposes to use. The time for submitting Contractor's plans may be extended by the Engineer at his discretion, if in his opinion such extension will not delay the progress of work under the contract.

All such plans shall be of sizes to be designated or approved by the Engineer and shall be clearly identified by item number, if any, and location of the equipment, material and apparatus in the work. The general character and arrangement of the shop and working plans shall be subject to the approval of the Engineer and before commencing such plans the Contractor, if requested, shall confer with the Engineer regarding the character, scale, arrangement, and completeness of such plans. The detailed shop plans shall give views, dimensions, instructions and references so that duplicate parts for repairs can be ordered and made from the drawings at any time in the future. The assembly and working plans shall show necessary details, and plans and elevations with dimensions, instruction and references for proper erection, installation and adjustment of the equipment.

The Contractor shall furnish to the Engineer a tabulated list of the minor equipment for which plans may not be required, showing the name of the manufacturer and the catalog number and type of equipment proposed, together with such dimensions, specifications, samples, or other data, as may be required to permit intelligent judgment of the acceptability of the same.

Machinery, equipment, accessories or parts to be furnished under this contract must be of current manufacture unless otherwise specified. Such material, whose manufacture has been discontinued or is scheduled to be discontinued within the life of the contract or duration of the maintenance bond, will not be accepted unless otherwise specified.

The contractor shall upon request furnish a certified statement from the manufacturer that any equipment, accessories or parts being furnished under the contract are in current production and that there are no present or near future plans to discontinue production of the item or items in question.

Approval of Contractor's Plans.

(4) The plans submitted by the Contractor for approval, as specified in Section (3), will be examined by the Engineer and it is understood by the Contractor in submitting the plans, that a reasonable amount of time will be necessary for their examination by the Engineer before they can be approved by him or returned for correction.

"All plans requiring structural design submitted by the Contactor shall be accompanied by the calculations for the work or design and shall be stamped by a registered structural engineer having a license to practice in the State of Illinois."

Unless otherwise instructed, the Contractor shall submit to the Engineer for examination three prints of each plan, and, as far as possible, all plans of any particular part of the structures or equipment, and of parts connected therewith, shall be submitted at the same time. After the plans have been examined as above mentioned, one print of each plan will be returned to the Contractor by the Engineer with his approval thereon, or marked with notations or corrections and changes that may be required. All plans not approved by the Engineer shall be corrected or revised by the Contractor as the Engineer shall direct and shall be resubmitted in the same routine as before. No orders for any work, materials, or equipment shown on any plans shall be given by the Contractor without the written consent of the Engineer.

No orders for any work, materials or equipment shown on any plans shall be given by the Contractor without the written consent of the Engineer prior to the time when such plans or equipment have been approved by him as specified. Prior to the approval of any such plans, any work which the Contractor may do on the structures or equipment covered by the same shall be at his own risk, as the Sanitary District will not be responsible for any expense incurred by the Contractor in changing structures or equipment to make the same conform to the plans as finally approved. No alterations of any plans shall be made by the Contractor after they have been approved except by the written consent of the Engineer.

The Contractor shall furnish the Sanitary District, as requested, and without extra charge therefor, such number of complete sets of prints of all plans, as approved, as the Engineer shall request and in general not less than eight, for office files and for use in the field. Erection plans shall have all match marks shown thereon.

After the work has been completed, the tracings of all plans for any and all work hereunder, made by or for the Contractor, shall be corrected by him so as to show all work as actually completed.

Prior to the issuance by the Chief Engineer of the final certificate specified in Article 35 of the General Conditions, the Contractor shall furnish to the Engineer, record prints, in duplicate on linen, of such drawings as have been submitted by the Contractor as specified in Section (3), as he may request.

Upon approval of the plans, lists, samples and other data submitted by the Contractor, the same shall become a part of this contract, and the equipment furnished shall be in conformity with the same; provided, that the approval of the above plans, lists, specifications, samples or other data shall in no way release the Contractor from his responsibility for the proper design, installation and performance of any material or equipment, or from his liability to replace the same should it prove defective.

Additional Sanitary District Plans.

(5) The Sanitary District will, for conditions noted in the Detail Specifications, prepare working plans supplementary to the plans previously listed herein, showing such additional and revised details for construction purposes not shown on the contract plans or which are shown as typical only and require revision and additions for construction purposes, as are required for furnishing and erecting the structures and equipment required under this contract. These working plans will be furnished to the Contractor by the Sanitary District within a reasonable time after approval by the Board of Trustees of the Sanitary District of the bond of the Contractor, and as required from time to time for the prosecution of the work.

The Contractor shall advise the Engineer in writing sufficiently in advance of the time when such plans will be required for the orderly progress of various portions of the work to permit their preparation and shall make no claims for damages for delays that may result from his failure to so notify the Engineer. These plans will include such details as are not shown on the contract plans and which the Contractor is not required to furnish, as specified in Section (3).

Checking Plans.

(6) The Contractor shall check all plans furnished by the Sanitary District and by himself for dimensions, quantities and co-ordination with other parts of the work under this contract, and shall notify the Engineer of all errors or omissions which he may discover by examining and checking the same. He will not be allowed to take advantage of any error or omission on the plans, as full instructions will be furnished by the Engineer should such error or omission be discovered, and the Contractor shall carry out such instructions as if originally specified. The work is to be made complete and to the satisfaction of the Engineer, notwithstanding any minor omissions in the specifications or plans.

Keeping Plans and Specifications on the Work.

(7) The Contractor shall keep on hand at the work for reference a complete copy of these specifications and a complete set of all plans of the work, and also copies of all plans furnished by the Contractor, all revised plans furnished by the Sanitary District and all orders issued to the Contractor by the Engineer that relate to the work under this contract.

Lines and Grades.

(8) A surface horizontal and vertical control system as required for the layout of the work under this contract shall be given by the Engineer. This horizontal and vertical control system must be verified by the Contractor and the Contractor will be entirely responsible for its correctness. All other horizontal and vertical control required for the complete layout and performance of the work under this contract shall be done by the Contractor at the Contractor's expense, and approved by the Engineer. The Contractor must verify and will be completely responsible for the correctness of all lines and grades, including any given by the Engineer.

In tunnel construction, each shaft shall be "plumbed" (line and grade transferred from the surface into the tunnel section) by the Contractor, and approved by the Engineer. The Contractor shall inform the Engineer, a reasonable time in advance, of the times and places at which he intends to do work.

At the Engineer's discretion, the Engineer will make occasional field checks of control work done by the Contractor. The Contractor shall correct any mistakes due to errors or omissions at his own cost and expense as ordered by the Engineer. Unless otherwise noted, all elevations shown on the plans and mentioned in the specifications are referred to Chicago City Datum (C.C.D.). The Sanitary District considers Chicago City Datum to be at Elevation 579.48 above New York Mean Sea Level, USC&GS 1929 adjustment (MSL-1929 adj).

Inspection and Testing of Materials and Equipment.

(9) All material and equipment furnished under this contract shall be subjected at all times during manufacture, fabrication and erection to such inspection and tests by the Engineer or his authorized representatives, as will give due assurance that the terms of the specifications are being complied with in all respects. Such inspection and tests shall be performed at the points of manufacture or fabrication, or in the field, as are herein specified therefor or as otherwise designated by the Engineer. Where inspections or tests are to be made at the point of the manufacture or fabrication, the Contractor shall in all cases give ample notice to the Engineer to permit such inspection and tests to be performed before painting is done and shipment is made and shall furnish to the Engineer copies, in triplicate, of all mill orders and invoices covering the same, to facilitate the identification of the material inspected.

All inspecting and testing of materials furnished under this contract will be performed by the Engineer or his duly authorized inspection engineers or inspection bureaus without cost to the Contractor unless otherwise expressly specified herein.

When inspection of materials and equipment is authorized in writing by the Engineer, it shall be the sole responsibility of the Contractor hereunder to keep the Engineer, or such duly authorized inspection engineers or inspection bureaus, fully informed as to when and where the material or equipment is to be inspected. All approved subcontractors shall be appropriately advised of this requirement. If any material or equipment is shipped to the site of the work without authorized inspection, it may be subject to rejection. Any additional expense to the Sanitary District for inspection of such material or equipment at the site of the work shall be borne by the Contractor.

All machining and preparation of test samples, required by the ASTM or other specifications and cited as standard for this contract, shall be done by the Contractor at his own expense.

All specifications of any society, institute or association hereafter referred to are hereby made a part of this contract the same as if written in full.

The following societies, institutes and associations will be hereinafter designated, by their initials, as follows:

Name	Designation
American Association of State Highway Officials	AASHO
American Institute of Electrical Engineers	AIEE
American Institute of Steel Construction	AISC
Air Moving and Conditioning Association, Inc.	AMACA

American Petroleum Institute	API
American National Standards Association	ANSI
American Society of Mechanical Engineers	ASME
American Society for Testing Materials	ASTM
American Welding Society	EEI
American Water Works Association	AWWA
Edison Electric Institute	EEI
Standard Specification for Road and Bridge Construction of the Department of Public Works and Buildings, Division of Highways, State of Illinois	IDH
Illinois Environment Protectional Agency	IEPA
Insulated Power Cable Engineers Association	IPCEA
Metropolitan Sanitary District of Greater Chicago	MSD
National Electrical Manufacturers: Association	NEMA
National Fire Protection Association	NFPA
Occupational Safety & Health Administration	OSHA
Steel Structures Painting Council	SSPC
U.S. Environmental Protection Agency	USEPA

Where reference is made to standard specifications of any of the above societies, institutes or associations, these references refer to the latest Standards and Tentative Standards of said society, institute or association in force on the date when bids on this contract were received; except that, if a revised specification is issued by said society, institute or association before completion of a part of the work affected by said specifications, the Contractor may, if approved by the Engineer, perform the part of the work affected in accordance with the revised specifications. In interpreting said standard specifications, the "Purchaser" shall be understood to mean the Sanitary District, and the "Manufacturer," the Contractor hereunder of any person or persons or corporation furnishing materials for or performing work under this contract.

For any material not covered by the designated specification of some designated society, institute or association, appropriate methods of testing and inspection to be designated by the Engineer shall be followed.

All samples for analysis and tests shall be taken in such manner as to be truly representative of the entire lot under test and shall not be worked on in any way to alter the quality before testing. Where expressly permitted by the Engineer in the case of materials taken from stock or for use in minor parts, certified analysis and tests of the manufacturer, furnished in triplicate, may be accepted in lieu of the tests prescribed above. In case the records of physical and chemical tests of stock materials are not available a reasonable number of tests shall be furnished to the Engineer free of charge as required by the Engineer to satisfy himself as to its quality.

Inspection and tests of fabricated parts and manufactured articles shall be made by such methods and at such times as to insure compliance with the specifications in all respects. Inspection of all metal work shall be made before painting.

Should the preparation of the material be at far distant or inaccessible points, or should it be divided into unreasonably small quantities, or widely distributed to an unreasonable extent, or should the percentage of rejected material be unreasonably large, the additional cost of extra inspection resulting therefrom shall be borne by the Contractor, the Engineer being sole judge of what is to be deemed extra inspection.

The Engineer or his authorized representative shall have full power to reject any and all material or equipment which fails to meet the terms of the specifications and such material or equipment shall be promptly removed from the work hereunder. All material or equipment which develops defects during the life of the contract, either before or after erection, shall be removed and replaced, notwithstanding that it may have passed the prescribed inspection and tests.

Inspection and Tests of Workmanship

(10) It is the intent, under this contract, to secure high class workmanship in all respects and that structures be substantially watertight. By substantially watertight is meant concrete structures with no appreciable leaks from cracks, porous places, h[illegible] expansion or construction joints, and metal [illegible] pipe lines with no leaking or sweating [illegible] or leaks through defective pipe materials.

Any imperfect work that may be discovered before the final acceptance of the work shall be corrected immediately. The inspection of any work shall not relieve the Contractor of any of his obligations to perform proper and satisfactory work, as herein specified, and all work, which, during its progress may become damaged from any cause, or fails for any reason to satisfy the requirements of the specifications shall be removed and replaced by good and satisfactory work without extra charge therefor.

The Contractor shall perform all tests which are specified under the various items of the contract. Any changes or repairs necessary to put all work and equipment in satisfactory adjustment and operating condition (except for changes of repairs of equipment furnished by the Sanitary District), whether due to defective material, design or construction, shall be done by the Contractor at no additional cost to the Sanitary District. In general, all mechanical and electrically operated equipment furnished and installed under the various items of the contract shall be given such operating tests as are necessary to demonstrate that it is in satisfactory operating condition and adjustment.

The Contractor shall furnish all tools, materials, labor and equipment, except as otherwise specified, necessary for performing all tests specified under this section and under the various items of the contract and for making all necessary repairs and adjustments (except for repairs and adjustments of equipment furnished by the Sanitary District), at no additional expense to the Sanitary District other than that specified to be paid under the various unit and lump sum prices of the contract. Power for testing equipment will be furnished by the Sanitary District, to the extent permitted by the Engineer, if Sanitary District power is available at the site of the work.

Measurement for Payment.

(11) When unit prices are specified, all measurements of quantities for payment under the unit price item or items of this contract shall be made by the Engineer in the manner specified, and the price or prices paid shall include the furnishing, delivering, erecting and connecting up of all tools, materials, equipment, apparatus and appurtenances; the furnishing of all labor and performance of all work required for the installation; and all plans, testing, painting, Contractor's bond, maintenance bonds where required, and collateral work necessary to complete the work as specified in the Detail Specifications. The cost of performing all work specified in the General Specifications and General Conditions, shall be included in the unit and/or lump sum price or prices specified in the Agreement (unless otherwise directly specified) and no additional payment will be made by the Sanitary District to the Contractor for performing said specified work. No "extra" or "customery" allowances for payment will be made under any item, unless directly specified therein, and no additional payment for work included under any item of this contract will be made under other items unless directly so specified.

Where payment by scale weight is specified under certain items, the Contractor shall provide suitable weighing equipment which shall be kept in accurate adjustment at all times. The weighing of all material shall be performed by the Contractor in the presence and under the supervision of the Engineer or his authorized representative.

Intent of Specifications and Plans.

(12) The specifications and plans are intended to cover the complete installation. It is not the intent to give every detail in the specifications and plans. The Sanitary District will not be responsible for the absence of any detail the Contractor may require, or for any special construction work, equipment, material or labor which may be found necessary as the work progresses. No additional compensation will be allowed the Contractor for any such special construction work, equipment, material or labor which may be found necessary for performing or completing any work hereunder unless it can be clearly shown, to the satisfaction of the Engineer, that such special construction work, equipment, material or labor is beyond the intent and scope of the plans and specifications, or is not included under the lump sum or unit prices specified in the Agreement. If this is shown, the payment for such special construction work, equipment, material or labor shall be made under Articles 7 and 8 of the General Conditions, after the additional cost has been agreed upon and a written order by the Chief Engineer has been issued.

Ground Surface and Underground Conditions.

(13) Where profiles of the ground or cross

sections showing typical elevations of the present ground and of the finished surfaces of cuts and fills adjacent to the structures to be built under this contract are shown on the plans hereto attached, the elevations are believed to be reasonably correct but are not guaranteed to be absolutely so, and together with any schedule of quantities, are presented only as an approximation. The Contractor shall satisfy himself, however, by actual examination of the site of the work, as to the existing elevations and the amount of work required under this contract.

Where test pits and borings have been dug on the site of the work, the results supplied to the District by the soils engineer may be given on the plans or are in file in the Engineer's Office for the information of the contractor. The District does not guarantee the accuracy or correctness of this information. If the contractor desires any additional information relating to the soils investigation, he should contact the soils consultant to obtain such information. The District does not guarantee the accuracy or correctness of any such information supplied by the soils consultant to the prospective bidder. The contractor must satisfy himself by making borings or test pits or by such other methods as he may prefer to determine the character, location and amounts of water, peat, clay, sand, quick sand, gravel, glacial drift, boulders, conglomerate, rock, gas and other material to be encountered and work to be performed.

Existing and Future Structures.

(14) Various underground, and overhead utilities and other structures are shown on the plans hereto attached. The location, material and dimensions of such structures, where given, are believed to be reasonably correct, but do not purport to be absolutely so. All known structures both under and above ground, either existing or under construction, except contractors' plants, are plotted on the plans and profiles for the information of the Contractor or are on file in the office of the Chief Engineer, but information so given is not to be construed as a representation that such structures will be found or encountered as plotted, or that no other such structures will be found or encountered. Other structures may also be encountered which may be built under existing or future contracts, or by other parties, which are not shown on the plans. All structures encountered shall be protected and supported, and, if damaged, repaired by the Contractor without charge therefor to the Sanitary District. The Contractor shall arrange with the owners of said structures for the shifting, temporary removal and restoration and protection of same where necessary for the prosecution of work under this contract, at no additional expense to the Sanitary District except as otherwise specified herein.

Where all or part of the site on which work is to be performed has been utilized under former contracts for the storage of Contractor's materials and for Contractor's temporary roadways and tracks, the Contractor shall make no claim for extra cost of his work due to encountering debris or other obstructions resulting from such use.

Space for Material, Equipment and Plant.

(15) The Contractor shall have the use of such available areas on unoccupied and unused property of the Sanitary District adjacent to or near the site of the work, for the storage of material and for field erection of plant and equipment as are not needed for other structures to be built under existing or future contracts, or for delivery of material and equipment under existing or future contracts, or for other purposes of the Sanitary District. All areas on Sanitary District property shall be used under conditions to be approved by the Engineer, and in no case will the Contractor be permitted to block access to other parts of the work under construction or to the treatment plant. The Contractor shall submit drawings showing the proposed layout of his plant to the Engineer for approval, if required. All other necessary or additional storage facilities shall be provided by the Contractor.

When considered necessary and ordered by the Engineer, the Contractor shall immediately remove or relocate any of his tracks, equipment, buildings or other structures which, in the opinion of the Engineer, constitute an obstruction or interfere with the proper carrying on of any other work, without additional charge to the Sanitary District.

Where the Sanitary District has prepared areas at the site of the work for use as parking spaces for the Contractor's forces, the parking of the cars of the Contractor's forces in locations other than in such parking areas will not be permitted.

Cleaning Work and Sites.

(16) The Contractor shall keep the site of the work and adjacent premises as free from material, debris and rubbish as is practicable and shall remove from any portion of the site, if, in the opinion of the Engineer, such material, debris or rubbish interferes with the operation of the existing plant or other contractors, constitutes a nuisance, or is objectionable in any way to the public. The Contractor further agrees to remove all machinery, materials, implements, barricades, staging, false-work, debris and rubbish connected with or caused by said work immediately upon the completion of the same and to clean all structures and work constructed under this contract to the satisfaction of the Engineer; regrade all areas which have been rutted or disturbed so that the areas will drain without pockets; and to leave the premises, upon completion of the contract, in at least as good condition as when he entered upon them.

Provisions for Delivery at Site.

(17) The Contractor shall make his own arrangements for delivery of materials and equipment to the site, except as may be otherwise stated in the Agreement.

Where the Sanitary District has railroad connections serving the site, the Contractor will be permitted the use of such tracks only to the extent that it does not interfere with the Sanitary District's operations. Any damage to plant tracks due to the Contractor's use other than normal wear shall be promptly corrected by repair or replacement to the satisfaction of the Engineer.

The Contractor, subject to the approval of the Engineer, will be allowed a reasonable use of any existing roadways that are under the jurisdiction of the Sanitary District. Any repairs or maintenance made necessary by the Contractor's use of any such roads shall be done by the Contractor without expense to the Sanitary District. The Contractor's use of the roads shall be strictly in conformity with conditions to be prescribed by the Engineer and shall not interfere with their use by the Sanitary District or other contractors. The Contractor shall so conduct his work as to keep all existing roads in continuous service, except as otherwise specified.

The Contractor shall provide and maintain at his own expense such other roadways or other means to obtain access to the work as he may require. Such roadways and other means of access may also be used by the Sanitary District or other contractors now or hereafter engaged upon work on this site.

Procedure and Methods.

(18) The attention of the Contractor is particularly called to the time allowed for the completion of the work included under this contract. To avoid delay in the completion of work hereunder, he shall submit the names of all sub-contractors and suppliers of material and equipment for approval within 10 days after the date of approval of his bond and shall place all orders for material and equipment within 5 days after receiving the approval of the Engineer. The Contractor's attention is further called to the fact that the Sanitary District may take over certain parts of the work under this contract for permanent operation as rapidly as completed in advance of the completion of the contract as a whole.

The Contractor shall determine the procedure and methods and also design and furnish all temporary structures, sheeting, bracing, tools, machinery, implements and other equipment and plant to be employed in performing the work hereunder, and shall promptly submit layouts and schedules of his proposed methods of conducting the work to the Engineer for his approval. The use of inadequate or unsafe procedures, methods, structures or equipment will not be permitted, and the Engineer may disapprove and reject any of same which seem to him to be unsafe for the work hereunder, or for other work being carried on in the vicinity, or for work which has been completed or for the public or for any workmen, engineers and inspectors employed thereon, or that interferes with the work of the Sanitary District or other contractors, or that will not provide for the completion of the work within the specified time, or that is not in accordance with all the requirements herein specified.

The Contractor shall employ and assign to work on this contract only, a qualified technical engineer, satisfactory to the Chief Engineer of the Sanitary District, to act as contact man with the Engineer.

Before starting construction, the Contractor shall submit his proposed order of procedure to the Engineer for approval. The construction of the various parts of the work shall be performed in such sequence that interference with operations of the Sanitary District or other contractors will be kept to a minimum.

The acceptance or approval of any order of procedure, methods, structures or equipment submitted or employed by the Contractor shall not in any manner relieve the Contractor of any responsibility for the safety, maintenance and repairs of any structure or work, or for construction, maintenance and safety of the work hereunder, or from any liability whatsoever on account of any procedure or methods employed by the Contractor, or due to any failure or movement of any structures or equipment furnished by him. When constructed, even though in accordance with the approval of the Engineer, should any structure or equipment installed hereunder afterwards prove insufficient in strength or fail on account of poor workmanship or any procedure or methods employed by the Contractor, such failure shall in no wise form the basis of any claim for extra compensation for delay, or for damages or expenses caused by such failure, or for extension of time for completion of this contract, or for material, labor or equipment required for repairing or rebuilding such structure or equipment, or for repairing or replacing any other work that may be damaged in any way by the failure or movement of any structure or equipment or by any other happening.

The Contractor shall, at his own expense, provide any necessary temporary blocking, supports or protection for all structures already constructed or now hereafter under construction, with which his work comes in contact, to prevent injury to the same, and shall make good at his own expense any damage done by him to any part of said structures or their appurtenances in unloading and installing any of the work, material, apparatus or equipment included under this contract, or in removing plant or other property or in cleaning up.

The Contractor shall furnish such protection as may be necessary against damage in any way to the work, material, apparatus or the equipment included under this contract before and after the same have been installed (including all necessary protection for structures and equipment which may be damaged by winter conditions), and shall be fully responsibile for such equipment until its final acceptance.

Handling Water at Treatment Plant Sites.

(19) The Contractor shall make all arrangements for handling and disposing of water entering the work to maintain safe, dry and satisfactory working conditions. He will be permitted a reasonable use of existing drainage ditches and the drains and appurtenances constructed under various items of this contract for the disposal of water under conditions satisfactory to the Engineer, except as otherwise specified. In using the drainage ditches and drains, the Contractor shall keep them free from concrete, clay or other deleterious substances, and if such substances are allowed to enter the drains, their use may be forbidden altogether by the Engineer. The discharge of water containing clay or other solid matter into the drainage system will under no circumstances be allowed. The Contractor shall be responsible for the care of all drains and appurtenances constructed under this contract during its entire life, and just prior to its completion, all drains and appurtenances shall be thoroughly cleaned of all debris, deposits or other substances which will interfere with their proper operation and all broken or damaged parts shall be replaced or repaired without cost to the Sanitary District.

Openings and Cutting and Fitting.

(20) The Contractor shall provide all openings and recesses in the concrete, brickwork and other parts of the work, that may be required for any class or part of the work to be furnished or performed hereunder, or that are ordered by the Engineer. He shall do all drilling, cutting, fitting, patching and finishing that may be required to make the various classes and kinds of work hereunder go together in a proper, workmanlike and finished manner.

All such work shall be performed with proper and suitable tools in a workmanlike manner. No cutting will be allowed except by the permission of and subject to the direction or approval of the Engineer. Where holes are to be cut through concrete walls or floor slabs, a core drill or saw shall be used to prevent spalling of the concrete.

The Contractor shall cut all openings required for setting inserts in concrete or brick masonry placed under other contracts. All cutting shall be confined closely within the limits required for installing the inserts. Any concrete or brick masonry removed beyond the required limits and any damage to existing structures or equipment resulting from the cutting of concrete or brick masonry, shall be promptly replaced or repaired by the Contractor at his own expense in such a manner as ordered by the Engineer. Inserts shall be grouted in, and the cutting shall be done so that the grout can be thoroughly bonded and keyed to the existing structure. Grout shall be so placed as to make watertight joints and shall be neatly finished off flush with the surface of the adjoining structure. Reinforcement steel which may interfere with the setting of inserts shall be removed from all openings cut in the concrete, unless otherwise specified or ordered.

The cost of making all pipe connections to work performed under other contracts shall be included as part of the work under the appropriate unit and lump sum items of this contract unless otherwise specified.

Water, Power and Sanitary District Equipment.

(21) The Contractor shall arrange for his own water supply, which shall be of quality to be approved by the Engineer, free from contamination.

The Contractor, if he so desires, will be permitted to use water from the Sanitary District mains where it is available and does not interfere with the work of the Sanitary District or the requirements of other contractors on the site. The Sanitary District, however, will not be responsible for any interruption of service, or possible inadequacy of the supply. The Contractor will be required to pay for the water so used from the Sanitary District mains at the current rate paid by the Sanitary District to the various municipalities for purchase of water, and shall, at his own expense, install a meter or meters of approved type for the measurement of the water so used. He will be required to make such temporary connections as he may need, subject to the approval of the Engineer, and to restore all existing facilities prior to the completion of the work at no additional expense to the Sanitary District.

The Contractor shall arrange for his own supply of power.

The Contractor will be permitted the use, without charge, of washrooms and toilets in existing Sanitary District buildings, as approved by the Engineer.

The Contractor will not be permitted to use any Sanitary District equipment or facilities except in case of emergency or as specified herein. If such equipment or facilities are used in case of emergency, the Chief Engineer shall first give his permission and shall determine the cost of such use.

The cost for use of its facilities shall be paid to the Sanitary District on bills rendered monthly.

Safety.

(22) The Contractor shall be responsible for the safety of the Contractor's employees, Sanitary District personnel and all other personnel at the site of the work. The Contractor shall have a competent safety engineer (s) on the job at all times while work is in progress. He shall be provided with an appropriate office on the job site to maintain and keep available safety records and up-to-date copies of all pertinent safety rules and regulations.

A resume of the qualifications of the Safety Engineer must be submitted to the District and approved by the Engineer prior to the start of any field work. This resume shall include such items as; experience, education, special safety and first aid courses completed, and safety conferences attended.

The safety engineer shall:

Be completely familiar with all applicable health and safety requirements of all governing legislation and ensure compliance with same.

Schedule and conduct safety meetings and safety training programs as required by Law.

Post all appropriate notices regarding safety and health regulations at locations which afford maximum exposure to all personnel at the job site.

Post the name, address and hours of the nearest medical doctor; name and address of nearby clinics and hospitals, and the telephone numbers of the fire and police departments.

Post appropriate instructions and warning signs in regard to all hazardous areas or conditions.

Have proper safety and rescue equipment adequately maintained and readily available for any contingency. This equipment shall include such applicable items as; proper fire extinguishers, first aid kits, safety ropes and harnesses, stretchers, life savers, oxygen breathing apparatus, resuscitators, gas detectors, oxygen deficiency indicators, explosimeters, etc.

Make inspections at least once daily to ensure that all machines, tools and equipment are in a safe operating condition; that all work methods are not dangerous; and that all work areas are free of hazards and submit to the Engineer each day a copy of his findings on an inspection check list report form.

Also submit to the Engineer copies of all safety records along with all safety inspection reports and certifications from regulating agencies and insurance companies.

The Contractor shall report to the Engineer all accidents involving injury to personnel or damage to equipment and structures. In addition, the Contractor shall furnish to the Engineer a copy of all accident or health hazard reports prepared for OSHA.

All personnel employed by the Contractor or his Subcontractors whenever entering the job site, any shaft, or tunnel headings shall be required to wear approved safety hats.

The Contractor shall comply with all requirements relating to noise levels as specified in OSHA.

When the work is located on or close to roadways, the Contractor shall provide all necessary traffic control for protection of the traveling public.

The Contractor shall comply with the provisions of "State of Illinois Manual of Uniform Traffic Control Devices" or other pertinent governing regulations for traffic control.

Where work is in tunnel or for excavations more than 10 feet in depth, the Contractor shall also provide the following safety equipment, all subject to the approval of the Engineer:

Adequate stretcher units placed in convenient locations adjacent to the work;

Oxygen deficiency indicators;

Carbon monoxide testers;

Hydrogen Sulphide detectors;

Portable explosimeter for the detection of explosive gases such as methane; petroleum, vapors, etc.

An adequate number of U.S. Bureau of Mines approved self rescuers in all areas where employees might be trapped by smoke or gas.

In tunnel work an additional explosimeter shall be provided at the heading at all times which will continuously monitor for the presence of explosive gases. This explosimeter shall be the type that automatically provides both visual and audible alarms.

No employee will be allowed to work in areas where concentrations of airborne contaminants exceed Federal threshold limits. Respirators shall not be substituted for environmental control measures and shall be used only as prescribed by OSHA.

Internal combustion engines other than mobile diesel powered equipment shall not be used underground. All mobile diesel powered equipment used underground shall be certified by the Bureau of Mines as prescribed in OSHA.

All internal combustion equipment shall be operated in such a manner as to prevent any health hazards to personnel from exhaust fumes.

All haulage equipment such as hoists, cages and elevators operating in excavations and shafts shall conform to all requirements described in OSHA.

In addition to the safety requirements herein set forth, the Contractor shall comply with the health and safety laws, rules and regulations of federal, state and local governments, including but not limited to:

Safety Rules – Metropolitan Sanitary District of Greater Chicago, dated March 1, 1970 and as subsequently amended;

The Illinois Health and Safety Act approved March 16, 1936, together with all Amendments thereto and all rules and standards implementing said Act;

The Federal Occupational Safety and Health Act of 1970, which includes "Safety and Health Regulations for Construction", together with all Amendments thereto and all rules and standards implementing said Act.

As-Built Drawings.

(23) Upon completion of the work under this contract, the Contractor shall furnish to the Sanitary District one complete set of As-Built drawings.

The original reproducible Contract Drawings will be made available to the Contractor by the Engineer upon which the Contractor shall make the necessary additions and corrections to show the As-Built conditions. The changes shall be made by using opaque black ink and standard drafting techniques. Each drawing changed or unchanged shall bear the notation AS-BUILT near the title block and shall be signed as to its correctness by the Contractor and submitted to the Engineer for approval.

The Contractor shall include in the appropriate pay items of this contract, all engineering and drafting costs required to produce these As-Built drawings.

Open Burning.

(24) The Contractor shall not dispose of any material, debris or rubbish by open burning on the site of the work or on any other site, and shall comply with all rules and regulations of the Illinois Pollution Control Board (IPCB) in effect and as may be amended during the course of the contract.

Equipment Manuals.

(25) In addition to the requirements specified in Section (3) of the General Specifications, the Contractor shall provide 9 copies of an Equipment Manual for all equipment furnished. The Manual shall consist of bulletins, certified manufacturers' prints, as-built drawings of equipment, and other pertinent data which provide all information necessary to install, service, maintain, repair, and operate each piece of equipment, and shall include parts lists, service and maintenance instructions, and performance data.

The Manual must be submitted and approved prior to the beginning of the Operation Test as specified under Section (10) and of the Operating Personnel Training as specified in Section (27) of the General Specifications. Only 2 copies of the Manual will be required for purposes of review by the Engineer with 9 approved copies to be delivered to the Engineer prior to operation testing and personnel training.

The Manuals shall be bound in vinyl multiring binders bearing the contract title and number on the cover and in the window on the binder backbone. The inserts shall be 8½" x 11" in size, with any larger sized inserts folded to 8½" x 11". The Manuals must include an index and tabbed sheets, which will contain item numbers and descriptions in sufficient detail for easy reference to any particular piece of equipment included in the Manual.

Posting of Project Signs.

(26) Prior to the start of construction, the Contractor shall erect two 4' x 8' signs on the job site for public viewing at locations designated by the Engineer. These signs shall be erected in accordance with regulations of the USEPA and IEPA for grant funded projects. These signs will be furnished to the Contractor by the Sanitary District at storage locations on District property.

For each sign, the Contractor shall furnish and install (2) 6" x 6" x 14' long dense structural grade Southern Pine mounting posts which are to be set 4 feet into the ground and 5 feet apart (center line to center line). The bottom of the signs shall be 6-feet above ground. The Contractor shall also furnish (4) 3/8" x 10" long mounting bolts with nuts and washers for each sign.

These signs shall be maintained by the Contractor for the duration of the contract. Upon completion of this contract and acceptance by the Sanitary District, the Contractor shall dismantle the installed signs and deliver them to a place to be designated by the Engineer. All material furnished by the Contractor shall become his property and the site shall be restored to its original condition.

Operating Personnel Training.

(27) It shall be the Contractor's responsibility to furnish necessary training and instruction to make supervisory and operating personnel completely familiar with the operation and maintenance of all equipment installed under this contract. This training and familiari-

zation shall include coordination of new with existing control.

Such time as is necessary shall be devoted to this requirement and a log shall be kept up to date by the Contractor of such training including date, duration, equipment and/or systems covered and party or parties conducting and attending the instructions. When all Operating Personnel Training is completed the Contractor shall submit the certified log to the Engineer.

Proprietary Designations.

(28) When proprietary specifications are used in the contract documents followed by an "or equal" clause, they are intended to establish a standard of quality and not to inhibit the use of products of other manufacture.

Therefore, all processes, materials, devices, details, or parts specified by proprietary name shall be understood to mean and permit the use of other processes, materials, devices, details, or parts that the Engineer shall determine to be fully equal in suitability, quality and durability to the processes, materials, devices, or parts herein specified. The Engineer shall be the sole judge in determining equals of proprietary specifications and his decision shall be final and binding to both parties.

The foregoing shall be adhered to unless specifically noted to the contrary in the Detail Specifications. Such note will refer to this section.

Fire or Other Emergency.

(29) In the event of fire or other emergency occuring at or about the site of the work, the Sanitary District, at its option, may summon such aid as it deems necessary. The Sanitary District reserves the right to pay any third party for emergency services so rendered, and the Contractor shall promptly reimburse the Sanitary District for the amount of such payment. No liability on the part of the Sanitary District for cause of damage shall be inferred as a result of such aid being summoned, nor as a result of payment being made for such aid, and the Contractor hereby agrees to indemnify, keep and save harmless the Sanitary District from all claims, judgments, awards and costs which may in anywise come against the Sanitary District by reason of its summoning such aid and/or paying charges therefor. In the event that the Contractor summons emergency aid, the Sanitary District, at its option, may pay any party for emergency services rendered, and the Contractor shall promptly reimburse the Sanitary District for the amount of such payment. No liability on the part of the Sanitary District shall be inferred as a result of such payment being made, and the Contractor hereby agrees to indemnify, keep and save harmless the Sanitary District from all claims, judgment, awards and costs which may in anywise come against the Sanitary District by reason of its paying for emergency services rendered.

APPENDIX I

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

GENERAL SPECIFICATIONS—SEWERS

INDEX

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

GENERAL SPECIFICATIONS – SEWERS

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(1) INTERFERENCE WITH OTHER CONTRACTORS

The Contractor shall so conduct the work that there shall be no interference with work which may be in progress under contracts with other contractors. In case of dispute between the Contractor and other contractors employed by the Sanitary District, the decision of the Engineer shall be final and binding on both the parties hereto.

The Contractor shall at his own expense repair any damage to machinery, equipment, masonry, buildings or other property of the Sanitary District or other owners or work under construction by other contractors occasioned by the Contractor in the execution of this contract. The disposal of tools, material, machinery and other supplies and appurtenances during storage and erection on the property of the Sanitary District or other owners shall be subject to the approval of the Engineer. The Contractor shall assume all responsibility for the security and safety of everything he may have on the property of the Sanitary District or other owners.

(2) EXAMINATION OF SITE

The Contractor is required to examine the site of the work and adjacent premises, the means of access to the site, and to make all necessary investigations in order to inform himself thoroughly as to the character and magnitude of all work involved in the complete execution of this contract; also as to the facilities for delivering, handling and installing the construction plant and other equipment and the conditions, and the difficulties that may be encountered in the performance of the work specified herein. No plea of ignorance of conditions that exist or that may hereafter exist, or of difficulties that will be encountered in the execution of the work hereunder, as a result of failure to make necessary examinations and investigations, will be accepted as a sufficient excuse for any failure or omission on the part of the Contractor to fulfill in every detail all the requirements of this contract, or will be accepted as a basis for any claim whatsoever for extra compensation or for an extension of time to complete the contract.

(3) LIMITS OF WORK

In order to prevent interference between contractors on adjoining sections, it is hereby agreed that the occupation of the space and the performance of work within a distance of fifty (50) feet on either end of the limits herein specified or shown on the plans, shall be such as the Engineer may direct. The Contractor shall perform any work ordered by the Engineer in writing, that is included within a distance of fifty (50) feet beyond either end of said limits, and such work shall become a part of this contract, and the Contractor shall be paid for said work performed by him at the unit prices herein specified for each class of work performed. In the event that the Contractor is ordered by the Engineer, in writing, he shall omit the doing of any work designated by the Engineer which is included within a distance of fifty (50) feet in either direction, from either of the end limits of this contract, and the Contractor shall not be paid for any work omitted and not performed by him, or for any anticipated profits on work omitted, and the work omitted may be performed by the Sanitary District or by any other of its Contractors. In any event, the Sanitary District shall not be liable to the Contractor for any damages or extra expenses for any decrease in the work to be performed hereunder, or for any expense that may result from any increase of the quantities of work, or from the performance of any work by the Contractor within a distance of fifty (50) feet beyond either end limit of this contract, in excess of the unit prices herein specified for work actually performed, nor shall the Sanitary District be liable for damages on account of the occupation by another contractor of the space within a distance of fifty (50) feet inside of either of the end limits of this contract.

(4) UNACQUIRED RIGHT-OF-WAY

All of the permanent structures to be constructed under this contract are located within the limits of public streets and highways and in right-of-way on private property which, if not now acquired, will have been acquired by the Sanitary District prior to the date of commencement of construction.

In case the Sanitary District fails to acquire any part of the right-of-way included within the limits of the work specified under this contract, as shown on the accompanying plans, on or before sixty (60) days after the approval of the Contractor's bond, and if, in the opinion of the Engineer, such failure to acquire such part constitutes or causes a delay in the commencement or prosecution of all or any part of the work under this contract, then the time of completion of the work to be performed under this contract shall be extended for such period of time as the Engineer may determine that the work under contract has been delayed by such failure to acquire the same, and such extension of time shall begin at the time of completion as specified in Article 23 of the General Conditions.

If such unacquired right-of-way is not acquired within nine (9) months after the approval of said bond, then this contract, insofar as it relates to work to be performed within the property where said right-of-way is unacquired, shall be null and void at the option of either party hereto, and the Sanitary District shall claim no damages against the Contractor for not performing any work on right-of-way which is unacquired, nor shall the Sanitary District be responsible for or pay any damages to the Contractor by reason of interference with his work due to the fact that all of said right-of-way has not been acquired, nor on account of anticipated profits on work of any kind not performed.

The Contractor will not be allowed to construct the work on private property until the easement has been obtained.

(5) LINE PIPES ON TUNNEL CONSTRUCTION

The Contractor shall place line pipes along the route of the work at such times and places as directed by the Engineer. The number of line pipes to be placed shall be determined by the length of the tunnel. Installation is to be at a rate of one (1) line pipe per one thousand (1,000) feet of tunnel on a straight line and one at each point of curvature and one at each point of tangency on a curve, all at locations designated by the Engineer. The size of line pipes shall be determined by the depth of the sewer tunnel to be constructed. The size shall be ten (10) inches finished diameter or smaller where the invert of the tunnel is one hundred (100) feet or less below the top of ground and ten (10) inches finished diameter or larger where the invert of the tunnel is more than one hundred (100) feet below the top of ground. The line pipes shall be made of steel. Line pipes shall be driven or placed by other methods in a vertical position from the surface of the ground to a point inside the structures to be built under this contract so that a plumb bob can be threaded through the pipe without contact with the pipe at any point. The top of each line pipe shall be provided with a standard screw cap, drilled and tapped for and furnished with a 1/2 inch plug. In addition, two (2) standard screw caps shall be furnished for use in checking the line. Each of the additional caps shall have holes drilled at locations ordered by the Engineer in order that a ~~plub~~ plumb bob wire may be threaded through any of the holes. If compressed air is used, each of the additional caps shall be drilled and tapped for and furnished with a 1/2 inch stopcock. The top of each line pipe shall be capped at all times, except when such pipes are being used for checking the line. The Contractor shall obtain any permits necessary for this work and shall repair all pavements damaged. The line pipes shall be removed for a distance of at least five (5) feet below the ground surface when not under pavement and at least two (2) feet below the top of any pavement. Where the line pipes project through the tunnel, the Contractor shall cut off the pipes to the outside neat lines of the tunnel and fill the opening with concrete and the balance of the pipe or the hole left by the removal of the pipe shall be filled with sluiced sand before the surface of the ground is restored.

(6) STRUCTURES ENCOUNTERED

Various underground, surface and overhead structures are shown on the plans hereto attached. The location and dimensions of such structures where given, are believed to be reasonably correct, but do not purport to be absolutely so. These structures are plotted on the plans and profiles for the information of the Contractor, but information so given is not to be construed as a representation or assurance that such structures will be found or encountered as plotted or that such information is complete or accurate.

The Contractor therefore shall satisfy himself by such means as he may deem proper as to the location of all structures that may be encountered in the construction of the work.

The plans do not show the location of underground or overhead utilities serving the properties adjacent to the sewer to be constructed, nor highway drainage systems.

All structures or obstructions encountered during the ~~performance~~ performance of the work under this contract, whether shown on the plans or not, shall be relocated or protected from injury by the Contractor, except as hereinafter provided.

(7) CARE OF STRUCTURES AND PROPERTY

All poles, trees, shrubbery fences, pavements, sewer, water, gas or other pipes, wires, conduits, culverts, drainage ditches and manholes, tunnels, tunnel shafts, buildings and all structures and property along the route of the sewer to be constructed shall be supported and protected from injury by the Contractor, during the construction and until the completion of said sewer and appurtenances. The Contractor shall be liable for all damages to such structures and property and shall save and keep the Sanitary District harmless from any liability or expense for injuries, damages or repairs to the same.

In open cut work, wherever sewer, gas and electric pipes or conduits cross the sewer trench without cutting through the section of the sewer to be built under this contract, the Contractor shall support said pipes and conduits without damage to them and without interrupting their use during the progress of work under this contract.

Where said pipes or conduits cross the trench cutting through the section of the sewer to be constructed under this contract, the Contractor shall notify the private individuals, utility company, city, village or township who owns the pipes or conduits in order to move or rearrange them and shall cooperate with said utility company, city or village, or township in preserving service through said pipes or conduits, and all in accordance with the provisions of the ordinances, easements and permits of the contract documents.

The Contractor shall conduct the work so that no equipment, material or debris will be placed on or allowed to fall upon private property in the vicinity of the work unless he shall have first obtained the owner's written consent thereto and shall have shown his written consent to the Engineer.

All streets, pavements, roadways, parking lots, sidewalks, parkways and private property shall be thoroughly cleaned of all surplus materials, earth, and rubbish placed thereon by the Contractor, and such streets, pavements, sidewalks, parkways and private property shall be restored to as good condition as before the commencement of the work. Where sod has been removed or killed, new live sod shall be relaid as hereinafter provided. Where the areas have been seeded, top soil equal to that removed shall be placed, fertilized, seeded and rolled to the satisfaction of the owner of the land, as hereinafter provided. All trees, shrubs, and plants damaged shall be replaced at the proper season of the year with live growing stock of the same kind and variety of reasonable size ordinarily used for planting purposes.

The Contractor shall make such changes in the location of all electric power conduits and cables and police and fire alarm electrical wires of the municipalities as may be rendered necessary by the performance of the work specified under this contract. Such changes shall be made at the places and in the manner designated by and be subject to the approval of the proper municipal officials, and the provisions of the ordinances, easements and permits of the contract documents.

The Contractor shall arrange with all persons, partnerships or corporations for the support, removal, relocation and/or maintenance of any conduits, wires, poles, pipes, gas mains, cables, or other structures within any portion of the streets, public alleys and highways and easements to be occupied or used during the performance of the work specified under this contract, and shall do all work necessary for such support, removal, relocation and/or maintenance of such conduits, wires, poles, pipes, gas mains, cables, or other structures encountered, as may be rendered necessary by the construction of said intercepting sewer and appurtenances.

The Contractor shall furnish all material and supplies, plant, staging and falsework, machinery, tools and implements, vehicles, cars and railroad tracks; in fact, all material and appliances of every sort or kind that may be necessary for the full and complete performance of this contract, and shall furnish and maintain, subject to the approval of the Engineer, all necessary barricades, and other protections, lights and signs, necessary for the proper protection of the public. The Contractor shall also furnish watchmen not only to protect the public, but to protect all materials, tools, machinery and equipment and all work performed by the Contractor until said work has been completed and accepted by the Engineer.

On all connection items, the Contractor shall make a preliminary trench excavation to locate the existing sewers and other utilities before he begins the actual work of excavation for the connection to be built at each location.

(8) WATER PIPES

Wherever, in the performance of the work specified under this contract, it shall be necessary to remove, alter or repair water mains in the streets, public alleys and highways of the municipalities, the Contractor will arrange for the removal, alteration or repair of such water mains, without extra charge to the Sanitary District, and in accordance with the rules, regulations and ordinances of the municipalities, under which this work is performed, subject to the approval of the proper municipal officials.

Wherever, in the performance of the work specified under this contract, it shall be necessary to remove, cut off or damage water service pipes in any way, the Contractor shall alter, repair or replace such water service pipes and connect the same to the water mains and shall in the meantime install and maintain temporary service in place of that interrupted, without extra charge to the Sanitary District. The Contractor shall perform all work on water service pipes in accordance with the rules, regulations and ordinances of the proper municipal officials.

Wherever it has been necessary to alter, repair or replace water mains or service pipes, the Contractor shall take adequate measures to disinfect the new section in accordance with AWWA standards. All work performed by the Contractor shall have the approval for standards and quality of the local public health agency having jurisdiction and shall be approved by them before placing the section in service.

(9) PUMPING, BAILING AND CLEANING

The Contractor shall at all times during construction provide and maintain ample means and devices with which to promptly remove and properly dispose of all water or sewage entering the tunnels, trenches, or other parts of the work, and keep said excavations as dry as possible until the structures to be built therein are completed. All water pumped or drained from the work shall be disposed of in a suitable manner without damage to adjacent property, or to sewers, pavements, electrical conduits, or other work or property. Until the acceptance of the work, the Contractor shall, if so ordered by the Engineer, keep the entire work pumped free of water and sewage and before the acceptance of any part of the work shall clean the entire length of such finished part of the work, to the satisfaction of the Engineer.

The Contractor shall make provisions to dispose of all accumulated surface water at the site. The Sanitary District does not and will not provide an outlet for or handle the disposal of any such accumulated surface water.

The Contractor shall place and maintain any temporary dams, flumes, bulkheads, or other structures, necessary to prevent water, from adjacent sections of the sewer or adjacent structures, from entering the work under this contract, and shall completely remove the same when ordered by the Engineer where emergency by-passing of sewage is required into either a receiving ditch, waterway or storm sewer, the Contractor shall chlorinate such flows as approved by the Engineer.

All expense incident to or caused by said water conditions or by such interruption of the work shall be included in the unit or lump sum prices herein specified.

(10) PLANT FOR TUNNEL CONSTRUCTION

Fireproof materials shall be used in all above ground tunnel plant structures, within 100 feet of the shaft. On all shafts, steel bracing and tight wood lagging will be required. In the tunnel construction, steel ribs and wood lagging will be permitted. The electrical service buildings may be constructed of either wood, steel or other material which, in the opinion of the Engineer, is acceptable.

An adequate ventilation system shall be provided to properly ventilate all sections of the tunnel in a manner satisfactory to the Engineer.

The Contractor shall have in operation in each heading at all times an audible automatic gas alarm. The alarm shall be Model No. 700 J-W Sentinal, Audible Combustible Gas Alarm as manufactured by Johnson & Williams, Inc., Mountain View, California, or an approved equal. In addition, the Contractor shall have on the job site approved portable testing equipment to measure for carbon monoxide and hydrogen sulphide gases and oxygen deficiency.

Sanitary conveniences for the use of all persons employed on the project shall be constructed and maintained by the Contractor in sufficient number in accordance with the State of Illinois Health and Safety Rules, and in such manner, and at such places as shall be approved by the Engineer.

Hoisting in shafts may be done by means of a crane upon written approval of the Engineer.

Cranes and other gasoline or diesel powered equipment must be kept 20 feet away from the shaft with the exhaust at least 30 feet away in order to keep the contaminated air away from the shaft area. However, in the event the Contractor elects to perform construction operations out of a single central shaft, cages must be used exclusively for hoisting men and materials during construction of the tunnels except during the construction of the shaft. Hoisting equipment shall be provided with all recognized safety devices including landing dogs at all landings, effective devices to prevent over-winding, and down speed regulators. Cages shall be of metal, fitted to metal guide bars running from top to bottom, safely constructed and properly equipped with strong metal covers, screens and automatic devices for the protection of persons riding in them.

An emergency exit shall be provided adjacent to each main shaft, in a manner satisfactory to the Engineer.

(11) PLAN OF TUNNEL FROM A CENTRAL SHAFT

If the headings exceed 1,000 lineal feet in length, the Contractor shall furnish a glass covered steel case at least thirty (30) inches by forty (40) inches of a type approved by the Engineer and shall mount the same in a conspicuous place near the top of shaft as soon as the shaft is constructed. The Contractor shall prepare a detailed plan on linen showing all parts of the shafts, plant and tunnels in the vicinity of the shafts and keep this plan complete and correct at all times, the Contractor shall keep this plan displayed in the above mentioned case.

(12) PROTECTION OF STREETS AND TRAFFIC

The Contractor shall make provisions, so far as is practicable, at all cross streets and private driveways for the free passage of vehicles and foot passengers by bridge or otherwise. Where bridging is impracticable or unnecessary, in the opinion of the Engineer, the Contractor shall make arrangements, satisfactory to the Engineer and the proper authorities, for the diversion of traffic and shall provide all material and signs and perform all work necessary for the construction and maintenance of roadways and bridges for the diversion of traffic. Where openings are made in or adjacent to any street, alley or public place, the Contractor shall at his own expense, furnish such barricades, fences, lights and danger signals, shall provide such watchmen, and shall take such other precautionary measures as are necessary for the protection of persons or property. All material excavated and the materials or plant used in the construction of the work shall be so placed as to safeguard the work and allow free access to all fire hydrants, water valves, gas valves, manholes or electric, telegraph and telephone conduits, and fire alarm and police call boxes in the vicinity. After completion of the work the Contractor shall remove all equipment, falsework, buildings, temporary protections, barricades, rubbish and unsightly materials that were created by his operations, and shall leave the work area and the adjacent premises in a clean and orderly condition.

The Contractor shall comply with the provisions of "State of Illinois, Manual of Uniform Traffic Control Devices" and any regulations for all traffic control devices erected on Sanitary District construction projects.

(13) REPAIRING OF PAVED STREETS AND SIDEWALKS

Roads or pavements, storm ditches, culverts, gutters, curbs, crosswalks and sidewalks destroyed or damaged by the Contractor, either in the construction of the work under this contract or by the hauling and storing of material other than that incidental to vehicular traffic on public streets and highways, shall be repaired or replaced by the Contractor without extra charge therefor.

If the destruction or damage is due to settlement caused by work in tunnel, the ground surface shall be brought to its original elevation and the pavement, storm ditches, culverts, gutter, curb, crosswalk or sidewalk shall be replaced immediately with new material by the Contractor.

If the destruction or damage is due to work in open cut, immediately after the trench or pits have been refilled, the paving, storm ditches, culverts, curb, gutter, crosswalk or sidewalk shall be temporarily restored and maintained by the Contractor in as near the original condition as possible, using old materials at hand or such new materials as are necessary to keep the street safe for traffic, until it is repaved or the curbs, gutters, crosswalks or sidewalks are reconstructed.

(14) NEW PAVEMENTS, GUTTERS, CURBS AND WALKS

The Contractor shall obtain the consent of the Engineer and the appropriate Municipal, County or State authority having jurisdiction thereover before constructing the permanent pavements, gutters, curbs, crosswalks and sidewalks in place of those destroyed or damaged. The Contractor shall construct the new pavements, gutters, curbs, crosswalks and sidewalks in a careful and thorough manner of like character to that destroyed or damaged or of such other material as the Engineer shall order, provided the use of such other materials will involve no greater expense to the Contractor

The use of old material removed from the work shall be subject to the inspection of the Engineer, and any material rejected shall be replaced with new material. Any deficiency shall be supplied with new material of approved quality. The materials used and the manner in which pavements, gutters, curbs crosswalks and sidewalks are restored shall conform to the requirements and specifications of the municipality or governmental agency under whose jurisdiction the work is done, and shall be subject to the approval of the Engineer. See Ordinances, Easements and Permits from the State of Illinois, County of Cook, Municipalities and other governmental agencies.

(15) HISTORICAL AND SCIENTIFIC SPECIMENS

The Contractor shall preserve and deliver to the Engineer any specimens of historic or scientific value encountered in the work as directed by the Engineer

(16) PLACING MATERIAL FURNISHED BY THE DISTRICT

The Contractor shall install in the work at locations to be indicated by the Engineer, any materials not included in this contract, or herein specified to be installed by the Contractor, which may be necessary to complete the work. All materials thus installed will be furnished at the site of the work by the Sanitary District at its own expense, but the Contractor shall perform such extra work in accordance with Article 7 of the General Conditions, "Extra Work". The Contractor shall carefully inspect all materials furnished by the Sanitary District at the time of delivery, shall reject and set aside all cracked, broken or otherwise defective pieces discovered by him, and shall notify the Engineer in writing of the same within twenty-four (24) hours after the inspection. The Contractor shall be responsible for all materials furnished by the Sanitary District, after they have passed the Contractor's inspection as being sound, until they have been accepted in the completed work. Any cracked, broken or otherwise defective pieces discovered after inspection by the Contractor shall be replaced at his own expense.

EARTH EXCAVATION–TUNNEL

(17) Work Included – Tunnel

Earth excavation in tunnel shall include the loosening, loading, removing and disposing in the specified manner of all materials, wet or dry, necessary to be removed for purposes of construction, the furnishing, placing and maintaining of all sheeting, bracing and lining, the pumping, bailing and cleaning, the protection of existing structures and utilities from injury, the protection and repair of street surfaces and sidewalks and all incidental and collateral work necessary to complete the entire work as specified.

(18) Lighting and Ventilation in Tunnel

All tunnel work shall be lighted with a sufficient number of electric lights to insure proper work and inspection. A supply of fresh air sufficient for the health, safety and efficiency of the workmen and engineers shall be provided at all times throughout the length of the tunnel and especially at the headings. Additional lights and ventilation shall be provided whenever the Engineer may direct.

(19) Shafts

The Contractor shall make all arrangements necessary for the location, construction and operation of the shafts.

The Contractor shall so excavate and support the surrounding earth so that at no time is there more than five feet, measured vertically, unsupported by bracing as approved by the Engineer.

In case the shaft is built outside the line of the tunnel, the tunnel connecting the shaft with the line of the finished work shall be constructed as provided in Section 7 of the General Specifications–Sewers.

The shaft shall be constructed of proper size and shape and in no case be less than 12 feet in diameter and shall be suitably equipped to allow the work to be carried on expeditiously.

An approved ladder as shown on the plans in a separate well lighted compartment shall be constructed in each shaft so as to provide safe entrance and exit. Suitable protection shall be installed at bottom of shaft to properly protect the men.

Hoisting in shafts may be done by means of a crane as described in Section 10 of the General Specifications–Sewers.

Upon the completion of the work, the Contractor shall remove any concrete as directed by the Engineer, and shall completely backfill all shafts, drifts and tunnels not part of the finished work.

Backfilling shall be done as specified herein under Sections 33 and 41 of the General Specifications–Sewers.

(20) Excavation In Tunnel

The tunnel shall be excavated and trimmed to such size and shape as will allow the placing of the full masonry section of the sewer to the specified tolerances of line and grade as shown on the plans after all lining is in place.

The Contractor shall so excavate the tunnel and support the surrounding earth that no movement of the earth over or adjacent to the work shall occur at any time and at no time will there be more than five feet, measured horizontally, unsupported by bracing as approved by the Engineer.

The Contractor shall use extreme care in excavating and trimming to insure that the full masonry section will be placed within the specified tolerances of the correct lines and grades of the finished structure.

If steel bracing is used, the full masonry section shown on the plans shall be placed inside any indentations in the body of the plates used to support the earth. Flanges or shapes may extend into the body of the masonry a distance not to exceed two (2) inches. If wooden bracing is used, no part thereof shall extend into the sewer section shown on the plans. No additional payment or allowance of any nature will be made for the use of steel plates or shapes for supporting the earth.

If permission is given the Contractor to excavate the tunnel for a specified distance without immediately placing the concrete lining, the proposed method of bracing the tunnel and the extra bracing necessary shall be submitted for approval.

In case, due to unforeseen conditions or otherwise, any movement of the earth over or adjacent to the work occurs, the Engineer may order any or all work under this contract stopped except that which assists in making the work secure and in preventing further movement of the ground over or adjacent to the work. The Contractor shall resume tunneling at the place at which movement of the earth over or adjacent to the work has occurred only when, in the opinion of the Engineer, he has taken all necessary precautions to prevent further movement.

The Engineer will keep a record of the elevation of all sewer, water and utility lines to detect any settlement of or damage to such utilities, and the Contractor shall immediately upon verbal notification from the Engineer, perform such work or make such arrangements that will restore any such damaged utilities and will insure against further settlement or damage.

(21) Sheeting, Bracing And Lining In Tunnel

The Contractor shall furnish, place and maintain all sheeting, bracing and lining required to support the sides, floor and headings of the excavation in tunnel.

On all shafts, steel bracing and tight wood lagging will be required. If the sewer is constructed with or without the use of compressed air, steel ribs and wood lagging will be permitted. Bracing in place supporting the earth shall not be removed except by permission of the Engineer.

A drawing showing the method and sizes of lining and bracing proposed to be used shall be submitted to and approved by the Engineer before the necessary materials or equipment is ordered by the Contractor.

Special care shall be exercised to insure that full bearing is obtained between the lining and sheeting and the earth.

If at any time the method being used by the Contractor for supporting any material or structure in or adjacent to any excavation is not reasonably safe, in the opinion of the Engineer, the Engineer may require and the Contractor shall provide additional bracing and support necessary to furnish the added degree of safety required by the Engineer. The Contractor shall provide such added bracing and support by such method approved by the Engineer as he may elect to use, but the taking of such added precautions shall in no way relieve the Contractor of his sole and final responsibility for the safety of lives, work and structures.

(22) Breasting

The Contractor shall at all times keep available near each heading sufficient breasting and bracing to secure the heading against soil movement.

(23) Unauthorized Excavation in Tunnel

Wherever excavation is performed outside of the specified outside dimensions of the masonry section to allow the placing of the sheeting, bracing or lining and whenever the Contractor is allowed to excavate beyond the lines of the finished work for his convenience, and whenever material outside of the specified outside dimensions of the section, caves or breaks into the tunnel, then the Contractor, without extra payment therefore, shall completely fill the remaining space with concrete of the quality specified for the sewer section or such other material outside of the lines of the finished work as the Engineer shall order.

(24) Disposal of Excavated Material – Tunnel

All excavated material, except that required for backfilling in open cut elsewhere on this work, and, except as stated in Section 15, of the General Specifications – Sewers, shall be removed from the site of the work as soon as excavated and shall be disposed of by the Contractor without additional charge therefor.

EARTH EXCAVATION–OPEN CUT

Sections 25 to 30 of the General Specifications–Sewers, inclusive, apply to the excavations for work in open cut shafts, pits or connections or excavations necessitated by cave-in.

(25) Work Included – Open Cut

Earth excavation in open cut shall include clearing the site of the work, the loosening, loading, removing and disposing in the specified manner all materials, wet or dry, necessary to be removed for purposes of construction, the furnishing, placing and maintaining of all sheeting, bracing and timbering; the pumping, bailing, fluming, cleaning, and care of existing structures and utilities; the protection and repair of street surfaces and sidewalks; backfilling and all incidental and collateral work necessary to complete the entire work as specified.

(26) Excavation – Open Cut

The excavation between the lines of sheeting shall be of sufficient width to permit the work to be constructed in the manner and of the size specified.

In all streets improved with any type of paving the Contractor shall, unless otherwise ordered by the Engineer, so excavate, sheet and brace the trench or pits that the maximum horizontal dimensions of the trench or pit at the surface of the ground shall not exceed the outside horizontal dimension of the structure plus one-tenth (1/10) of the distance from the street surface to the top of the masonry.

Top soil shall be stripped off separately and stored for replacement of top surface over the backfill.

(27) Sheeting, Bracing and Timbering

The Contractor shall furnish, place and maintain all sheeting, bracing and timbering required to properly support trenches and other excavations in open cut and to prevent all movement of the soil, pavement, or utilities outside of the trench or pit. Sheeting, bracing and timbering shall be so placed as to allow the work to be constructed to the lines and grades shown on the plans and as ordered by the Engineer.

All sheeting in contact with the concrete or masonry shall be cut off as directed by the Engineer and left in place.

If at any time the method being used by the Contractor for supporting any material or structure in or adjacent to any excavation is not reasonably safe in the opinion of the Engineer, the Engineer may require and the Contractor shall provide additional bracing and support necessary to furnish the added degree of safety required by the Engineer. The Contractor shall provide such added bracing and support by such method approved by the Engineer as he may elect to use, but the taking of such added precautions shall in no way relieve the Contractor of his sole and final responsibility for the safety of lives, work and structures. The use of such additional bracing and support shall be without additional cost to the Sanitary District. The failure of the Engineer to order the aforementioned additional bracing shall in no way relieve the Contractor of his sole and final responsibility.

(28) Backfilling

All backfilling of excavations in open cut on paved roads shall be done as specified in Sections 33 and 41 of the General Specifications–Sewers. All excavations in open cut shall be backfilled to the line and grades shown on the plans or to the ground surface as found where no lines or grades are shown on the plans. The backfilling shall be done as compactly as possible, and the material shall be well tamped in such a manner as to allow as little after-settlement as possible.

After the sewer or structure has been constructed and the concrete has hardened to the satisfaction of the Engineer, the Contractor shall backfill the trench in such a manner that will cause no damage to the sewer or structure by the shock of falling earth or otherwise. The backfill shall be deposited in such a manner as to prevent eccentric loading and excessive stress on the sewer or structure. Top soil stripped in excavation shall be replaced on top of the backfilled material.

All backfilling operations shall be accomplished as speedily as possible, the trench being filled as soon as the concrete is sufficiently set. In streets and in other places when the Engineer shall so order, the backfilling shall not be left unfinished more than four hundred (400) feet behind the completed masonry or pipe work.

Where existing structures have to be removed and backfilled or where additional fill or mounds are placed around manholes or ~~[illegible]~~ top soil equal in depth to that in surrounding area shall be placed in the backfilled section and fertilized, seeded and rolled to the satisfaction of the owner of the land.

Structures

All fill slopes shall be not steeper than 3 horizontal to 1 vertical, unless otherwise directed by the Engineer.

(29) Disposal of Excavated Material

All excavated material except that required for backfilling in open cut, and except that stated in Section 15 of the General Specifications Sewers shall be removed from the site of the work and shall be disposed of by the Contractor without additional charge therefor.

As far as possible, all excavated material, except that required for backfill, shall be removed from the site of the work as soon as excavated.

(30) Unauthorized Excavation

Wherever excavation in open cut is performed without authority, beyond the lines and grades shown on the plans or as directed by the Engineer, the Contractor shall refill without extra payment therefor, all such excavated space beyond such lines and grades with concrete or other material as the Engineer may direct.

ROCK EXCAVATION IN OPEN CUT AND TUNNEL

(31) Description

All rock excavation shall be performed by the Contractor in accordance with Sections 17 to 30, of the General Specifications – Sewers, inclusive, as far as they apply and supplemented by the specifications for each excavation.

(32) Blasting

Extreme care shall be exercised in connection with all blasting necessary under this contract. Signals of danger shall be given and displayed before the firing of any blasts; and the Contractor shall conform his acts to and obey all rules and regulations for the protection of life and property that may be required by law or that may be made from time to time by the Engineer relative to the storing and handling of explosives and the firing of blasts. Whenever it becomes necessary to blast in tunnel, the amount of air used for ventilation shall be increased and the amount of explosive used at any one time shall be kept to a minimum and shall be so placed as to minimize the amount of rock breaking outside of the lines of the finished work. No blasting shall be done adjacent to any part of the completed sewer or other structure and the material surrounding or supporting the same shall not be damaged by blasting. In case injury occurs to any portion of the sewer or other structure or to the material surrounding or supporting same, due to explosions or blasting, the Contractor, without extra payment therefor, shall rebuilt the sewer or other structures and shall replace the material surrounding or supporting same, and shall furnish such material and perform such work or repairs and replacements as the Engineer may order.

The Contractor shall employ only experienced and qualified dynamite workmen to handle all powder and caps. Only licensed dynamite workmen detailed to dynamite magazines shall have access to these buildings.

The Contractor shall comply with the provisions of An Act Regulating the Manufacture, Possession, Storage, Transportation, Use, Sale or Gift of Explosives (Illinois Rev. St. Ch. 93, Section 143-156, approved July 12, 1939, and as amended). The Contractor shall obtain an Explosives License from the Department of Mines and Minerals, State of Illinois, in compliance with said Act, and submit a reproduced copy to the Engineer before proceeding with the storage of dynamite on this contract.

In addition, the Contractor shall comply with all the provisions relating to explosives of the State of Illinois Health and Safety Act and all requirements of authorities having jurisdiction in the area.

The Contractor agrees to indemnify and save the Sanitary District harmless against all claims for damages to real or personal property or for injuries to persons, or deaths caused in any manner whatsoever, by explosions, blasting, handling or storing of explosives for the work hereunder.

SAND, GRAVEL OR LIMESTONE BACKFILL

(33) Description

All excavations under or adjacent to any type of pavement, including concrete, concrete base, bituminous, gravel or crushed stone, shall be backfilled as follows:

Sand, gravel, limestone screenings or crushed limestone backfill shall be used from the bottom of the sewer trench or excavation up to a point where the distance to the top of the natural ground surface equals the distance from the nearest edge of the sewer trench or excavation to the pavement. ~~The sand, gravel, limestone screenings or crushed limestone shall be either torpedo, lake, bank, or mine run sand, sand and gravel.~~ It may contain material passing a No. 200 mesh sieve not to exceed ten percent by weight, but shall contain no organic matter. Material passing a No. 16 mesh sieve shall not exceed Not less than eighty-five percent by weight. ¶Eighty-five percent of the material shall pass the one inch sieve and shall not contain stone larger than four inches. Backfill shall not contain any frozen or cemented material.

Sand and gravel material shall be obtained from an approved sand and gravel pit or limestone screenings or crushed limestone from an approved material yard or quarry.

Material removed from the excavated trench will not be allowed as backfill, unless it is approved by the Engineer as meeting the above specifications.

Cinders will not be approved as backfill.

PIPE SEWER

(34) Gasket Specifications

Gasket stock shall be a synthetic rubber compound in which the elastomer is Neoprene, exclusively. Said compound shall contain not less than 50% by volume of Neoprene and shall contain no factice, reclaimed rubber or any deleterious substances. The stock shall be extruded or molded and cured in such a manner that any cross-section will be dense, homogeneous and free from porosity, blisters, pitting and other imperfections. The stock shall be extruded or molded with smooth surfaces to the required diameter within a tolerance of ± 1/32" at any cross-section. The Compound shall meet the following physical requirements when tested in accordance with the appropriate ASTM standards.

TEST REQUIREMENTS

Tensile strength – 1500 psi minimum, ASTM Test Standard D412.

Elongation at Break – 425% minimum, ASTM Test Standard D412.

Shore Durometer Type A-45 ± 5 for pipe diameters less than 90" (55± may be used for pipe diameters over 90"), ASTM Test Standard D2240.

Compression Set – 20% maximum when compressed 22 hours at 158° F. ASTM Test Standard D395 Method B.

Accelerated Aging – 20% maximum tensile, 40% maximum elongation deterioration, 15 points maximum increase in hardness, all determined after oven aging for 70 hours at 212° F. ASTM Test Standard D573.

Liquid Immersion, Oil – 80% maximum volume change after immersion in ASTM Oil No. 3 for 70 hours at 212° F. ASTM Test Standard D471. Test specimens shall have a height or thickness of 0.08" ±0.005". The test specimens shall be circular discs cut from the gaskets. The specimen diameter shall be that of the cross-section of the gasket.

Liquid Immersion Water – 15% maximum volume change after immersion in water for 7 days at 158° F. ASTM Test Standard D471. Test specimens shall have a height or thickness of 0.08" ±0.005" (See note 4 under Section 7 of ASTM D471). The test specimens shall be circular discs cut from the gaskets. The specimen diameter shall be that of the cross-section of the gasket.

Ozone Cracking – no visible cracking at 2 times magnification of the gasket after 100 hours exposure in 3 ppm ozone concentration at 100° F. Testing and inspection to be on a gasket loop mounted to give approximately 20% elongation.

Durometer "A" – Hardness increase after 48 hours at + 14° F. + 15 points maximum.

The Contractor shall furnish certified copies of laboratory reports from his gasket supplier indicating conformance with the above requirements for each shipment of gaskets. A minimum of 2 tests for each pipe diameter shall be performed at the Contractor's expense on gaskets selected at random by the Engineer. Tests shall be performed by an independent testing laboratory and shall include all the tests listed above.

Each gasket shall be permanently marked with the manufacturer's trademark or name, date of manufacture, and the initials of the Metropolitan Sanitary District. All gaskets shall be stored in a cool place, preferably at 70° F. or less and in no case shall the gasket for joints be exposed to direct rays of the sun for more than 72 hours.

No more than two (2) vulcanized joints will be permitted on any one gasket.

(35) Laying Concrete Pipe in Open Cut

(a) Excavation

The trench shall be excavated in accordance with the depths and widths shown on the plans. Trench widths in excess of those shown on the plans will not be permitted.

Steel or wood sheeting shall be furnished and installed as required and its use shall be determined by the ground conditions encountered, easement agreements as specified or as directed by the ENGINEER and as shown on the plans.

Dewatering operations sufficient to maintain the water level at or below the surface of trench bottom or base of the bedding course shall be accomplished prior to placement of pipe or concrete, if not performed prior to excavation and placing of the bedding as called for on the contract plans. The dewatering operation, however accomplished, shall be carried out so that it does not destroy or weaken the strength of the soil under or alongside the trench. The normal water table shall be restored to its natural level in such a manner as to not disturb the pipe and its foundation.

(b) Laying Pipe

The concrete pipe shall be laid to the lines and grades shown on the plans.

Where practicable, pipe shall be laid with the bell or groove end at the advancing end of the pipe. Before laying, the joint surfaces shall be clean and free of all dirt and other foreign material. The gasket and the joint surfaces of the pipe to be laid shall be lubricated and the gasket properly placed in the groove on the spigot or tongue end. The pipe shall then be laid and pulled firmly into position. Care shall be exercised to see that the pipe is straight and level as the spigot enters the bell. The position of the gasket shall be checked with a feeler gauge to see that it is properly positioned.

If adjustment in the position of a length of pipe is required after it has been laid or if the gasket is found to be out of place, the length of pipe shall be removed, cleaned and rejointed as for a newly laid pipe.

Concrete cradle as shown on the plans shall achieve a compressive strength of 2,000 pounds per square inch prior to backfilling of the trench over a level as shown on the plans above the top of the pipe. Backfill below a level as shown on the plans above the top of pipe may take place after the concrete has achieved a sufficient initial set so that no damage to the concrete will occur when placing the backfill.

(36) Pipe Grade for Sewer in Open Cut

The tolerance in the grade of installed reinforced concrete pipe shall comply with the following:

The invert of the sewer after the pipe is in place shall be such that after flooding, the flood water will drain off so that no remaining puddle of water will be deeper than 1/2" on pipe 36 inches internal diameter or smaller, and 3/4" on pipe larger than 36 inches internal diameter. Any section of pipe that does not comply with this requirement shall be replaced at the Contractor's expense.

(37) Pipe Grade in Tunnel and Jacking

The tolerance in the grade of installed reinforced concrete pipe shall comply with the following: Departure from established grade – 2", Departure from established line – 3".

The return to established line and grade shall be at a rate no greater than 3" per 100'.

Any pipe placed which does not comply with this requirement shall be replaced at the Contractor's expense.

(38) Setting Line and Grade

The Contractor is responsible for setting line and grade from the information included in the Plans and Contract Documents, and in accordance with Section 8 of the General Specifications (Construction Contracts,) "Lines and Grades." No payment in addition to the price bid for the respective items will be allowed for setting line and grade.

The control of vertical and horizontal alignments shall be accomplished by the use of a laser beam instrument. The Contractor shall comply with the provisions of "an Act to Require Registration of Laser Systems . . ." Approved August 11, 1967, by the Illinois State Legislature and shall submit to the Engineer a reproduced copy of the acknowledgement of registration from the State Department of Public Health.

(39) Clay Sewer Pipe

The Contractor shall furnish and lay clay sewer pipe in accordance with the provisions for concrete pipe. See Sections 35,36,37 and 38 of the General Specifications–Sewers and as shown on the plans.

All pipe and specials shall conform to Specifications ASTM C13 or ASTM C200, as shown on the plans. Joints shall conform to ASTM Specification C425, type 3.

(40) Concrete Sewer Pipe

All reinforced concrete circular pipe shall be provided with bell and spigot or tongue and groove type joints for use with rubber gaskets as hereinafter specified. Excessive shrinkage cracks in the bell and spigot or tongue and groove ends or excessive bleeding at form ends which expose aggregates or create voids, or other defects or damage to the end of the pipe which would prevent making a satisfactory joint, as determined by the Engineer, shall be deemed reason for rejection of the pipe. The pipe shall have a preformed groove on the tongue or spigot face of each pipe section to properly position and confine the rubber gaskets in the annular space.

All reinforced concrete pipe shall conform to ASTM Specification C76. The pipe joints shall conform to ASTM Specification C361. All reference to a specific class of pipe and wall thickness shall conform to the requirements of that specified under ASTM Specification C76. The reinforcement steel in the joint shall be tied to the pipe barrel steel as called for in ASTM C361.

Gaskets for concrete pipe shall conform to "Gasket Specification", Section 34 of the General Specifications–Sewers. The gaskets shall be circular in cross section and shall be of sufficient cross-sectional area and volume so that when the joint is assembled, the gasket will be compressed to form a water-tight seal. Gaskets shall be extruded or molded and cured in such a manner that any cross-section will be dense, homogenous and free from porosity, blisters, pitting and other imperfections. The gaskets shall be molded or extruded to the tolerance as specified.

Any foreign material which adheres to the pipe and interferes with the proper seating of the gasket shall be removed. No cracked, broken or otherwise defective gaskets shall be used in this work. As the work progresses, the interior of the pipe shall be cleaned of all dirt and all other superfluous material.

Lubricant for use with the gasket shall be equal to the vegetable oil soap as manufactured by Davis Young Corp., Fort Wayne, Indiana, or a Bentonite Slurry diluted to a paste of consistency satisfactory to the Engineer. No petroleum product shall be used as a lubricant.

The Contractor shall submit to the Engineer for approval, detailed drawings of the pipe and pipe joint to be furnished and placed under this contract, including the dimensions of the rubber gasket and the joint in the assembled pipe position.

A tapered lifting hole in concrete pipe 36" in diameter and larger as indicated on the plans, if used, shall be filled with a fitted precast tapered concrete plug, coated with mastic and driven into place with wooden mallet. For concrete pipe placed in open cut the top of the plug shall be covered with cement mortar and hand trowelled so as to cover at least an area three inches greater than the opening. No lifting holes shall be placed in concrete pipe less than 36-inches in diameter.

The supplier of reinforced concrete sewer pipe shall submit for approval the design of pipe sizes not listed in the tables of ASTM C76. The information submitted shall show wall thickness, concrete strength, and the area, type, placement and strength of the steel reinforcement and shall meet the D-load strength test requirements as called for in the ASTM tables.

Reinforced concrete sewer pipe delivered to the job site shall be not less than ten (10) days old from date of manufacture and except for closure pieces, shall be not less than 6-feet nor more than 12-feet long unless otherwise approved by the Engineer.

On each reinforced concrete pipe manufactured, the following items shall be clearly marked on the interior surface of the pipe: (1) class and size of pipe; (2) Date of manufacture; (3) Name or trademark of the Manufacturer.

No reinforced concrete sewer pipe shall be delivered to the job site without the M.S.D. inspector's stamp affixed thereon, and shall be subject to re-inspection upon delivery to the job site.

(41) Backfill

In locations where the Permits, Easements, Ordinances or the Detail or the General Specifications require sand or other granular backfill material shall be as specified in Section 33 of the General Specification–Sewers.

Where sand or other granular backfill is not required, regular backfill may be used. Regular backfill shall be a uniformly divided material free from debris, stones larger than 6", objectionable organic matter and frozen materials and must be capable of compacting to a dense, stable backfill free of after-settlement.

Backfilling, unless otherwise specified, shall take place in accordance with Section 28 of the General Specifications–Sewers or in accordance with applicable easements, ordinances or permits. The Contractor's attention is directed particularly to the backfill requirements of the State Highway Permit.

In locations where it is not specified that sheeting must be left in place, sheeting shall be extracted.

Sheeting shall be extracted where practicable ahead of the backfilling where this procedure can progress without endangering the side of the excavation and in such a manner as to leave no voids in the space previously occupied by the sheeting.

Sheeting extracted after backfilling shall be removed in such a manner as to preclude leaving voids in the space previously occupied by the sheeting and in such a manner as to be consistent with Sections 26 and 27 of the General Specifications--Sewers.

IRON CASTINGS AND MISCELLANEOUS METALS

(42) Description

The Contractor shall furnish, deliver and place iron castings, including manhole frames and covers, and miscellaneous metal parts, and such other iron castings and metal parts as are shown on the plans or as ordered by the Engineer. All pieces shall be plainly marked with the piece mark as called for on the plans. Painting, if required, shall be performed as called for in the plans and specifications.

(43) Material and Workmanship

All castings shall be of tough, close-grained gray iron, free from blowholes, shrinkage cracks and cold shuts. They shall conform to a suitable grade of the "Tentative Specifications for Gray Iron Castings," ASTM A48. They shall be sound, smooth, clean and free from blisters and all defects. All castings shall be made by the cupola process. No plugging of defective castings will be permitted. Where malleable castings are required they shall be furnished and installed hereunder and shall conform to the "Standard Specifications for Cupola, Malleable Iron," ASTM A197.

All castings shall be made accurately to dimensions shown and shall be placed, chipped, filed or ground where marked or where otherwise necessary to secure perfectly flat and true surfaces. Allowance for shrinkage shall be made in the patterns so that the specified thickness shall not be reduced. Manhole covers shall be true and shall seat at all points. All drilling and tapping shall be carefully and accurately done.

All wrought-iron parts shall be made of genuine wrought-iron conforming to the requirements of the "Standard Specifications for Refined Wrought-Iron Bars and Wrought-Iron Plates," ASTM A189.

Steel parts shall be open hearth medium steel of quality conforming to the "Standard Specifications for Structural Steel for Buildings," ASTM A36.

All parts called for on the plans as galvanized shall be coated in accordance with "Zinc Coating on Standard Steel Shapes." ASTM A123. All galvanized metals whose coatings are damaged during shipment or installation, shall be touched up with MSDGC 117 Zinc rich primer paint.

Bronze bushings shall be of good quality phosphor-bronze. All parts called for as chromium-nickel steel shall be made of a ferrous alloy approved by the Engineer.

The Contractor shall notify the Engineer when castings and material parts are ready for inspection. See Section 9 of the General Specifications (Construction Contracts), "Inspection and Testing of Materials".

(44) Bolts and Nuts

Stud, tap and machine bolts shall be of specified wrought-iron or of specified structural steel of rivet quality unless otherwise specified. In general square heads and hexagonal close fitting nuts shall be used. All threads shall be clean cut of the U.S. standard sizes.

(45) Inserts

All inserts to be imbedded in the concrete shall be heavily galvanized malleable castings suitably normalized and of a type approved by the Engineer.

(46) Cast Iron Pipe

All cast iron pipe shall be furnished in accordance with ASA Specification A21.6 or A21.8 with the type of joint as specified in the Detail Specifications and/or shown on the plans. Pipe shall be furnished in full lengths except where shown on the plans in lesser lengths or where necessary to make closure. Wall thickness designated by a class number shall be based on ASA Manual of Design A21.1.

All fittings shall conform to ASA Specification A21.10 at the pressure rating as specified in the Detail Specifications and/or shown on the plans. Where ASA A21.10 specification is not applicable, the fittings shall conform to ASA B16.1 Specification.

, All rubber gasket joints for cast iron pipe and fittings shall conform to ASA Specification A21.11.

Fittings for pipes over 12 inches in diameter shall be Class B. Fittings for pipes 12 inches in diameter or less shall be Class D.

Wall pipes and wall sleeves shall be furnished with intermediate wall collars and shall have end types as shown on the plans and shall be Class B except where they extend beyond the outside surface of the wall in which case they shall be Class D.

Pipe and fittings shall be furnished bituminous coated inside and outside unless otherwise specified in the Detail Specifications and/or shown on the plans.

Cement linings specified in the Detail Specifications and/or shown on the plans shall conform to ASA Specifications A21.4. Pipe furnished with cement lining shall be bituminous coated on the outside.

Ductile Iron Pipe specified in the Detail Specifications and/or shown on the plans shall conform to ASA Specification A21.51 with all other requirements as listed above for cast iron pipe, except for wall thickness which shall be designated by a class number based on ASA Manual of Design A21.50.

(47) RESTORATION WORK

The Contractor's attention is directed to Section 7 of the General Specifications–Sewers, Care of Structures and Property.

Restoration work shall follow construction work as the work progresses and be completed as soon as possible. Restoration work shall not be delayed and shall be completed no later than thirty (30) days after sewer or structure is in place. Any testing or further inspection necessary for final completion and inspection of the sewer or structure shall not be cause for any delay of restoration work required under this contract. This provision for restoration shall include all public and private property which was affected by the Contractor's construction operations. Such final restoration that cannot be performed within the thirty day period due to adverse weather conditions may, upon written request, including a proposed procedure and time schedule, be performed as approved by the Engineer. Any delayed restoration will be contingent upon providing suitable safe temporary facilities without inconvenience or nuisance in the interim.

The Contractor shall maintain existing surface and subsurface drainage conditions in all areas along the line of the work, including highway ditches, storm sewers, culverts, natural terrain, field tile systems, etc.

Whenever public or private property is so damaged or destroyed, the Contractor shall at his own expense, restore such property to a condition equal to that existing before such damage or injury was done by repairing rebuilding, or replacing it as may be directed, or he shall otherwise make good such damage or destruction in a manner acceptable to the Engineer. If he fails to do so the Engineer may, after the expiration of a period of thirty (30) calendar days after giving him notice in writing, proceed to repair, rebuild, or otherwise restore such property as may be deemed necessary, and the cost thereof shall be deducted from any compensation due, or which may become due the Contractor under this Contract.

This provision for restoration work shall apply to all Items listed in the Proposal.

(48) TESTS

An infiltration test shall be made by the contractor in the presence of the Engineer after the first one thousand linear feet or less of sewer is completed, as ordered by the Engineer. Additional tests of the type ordered by the Engineer will be required for each succeeding one thousand linear feet or less, as ordered by the Engineer. A final test of the type ordered by the Engineer will be required prior to final acceptance of this contract. All tests will be conducted in a manner to minimize interference with the contractor's work or progress. No additional pipe shall be laid until the infiltration test on the section tested is satisfactory.

Where the depth of the ground water is not sufficient to completely submerge the section to be tested, an exfiltration test shall be used in place of an infiltration test when ordered by the Engineer. The Contractor shall be allowed additional payment for exfiltration tests in addition to the prices bid for sewer Items. The additional payment shall be the actual cost of the work to the Contractor and shall be determined on a time and material basis for labor, material and equipment.

No additional payment for infiltration tests in addition to the prices bid for Sewer Items to be tested as called for in the Detail Specifications will be allowed.

Personnel for reading measuring devices will be furnished by the Engineer, but all other labor, equipment, material and water, including gauges and meters, will be furnished by the Contractor.

Infiltration tests will be made by measuring the infiltrated flow of water over a measuring weir set up in the invert of the sewer a known distance from a limiting point of infiltration. Exfiltration tests will be made by bulkheading the section to be tested and admitting water to the lower end allowing air to escape at the upper end until the sewer is filled. The bulkheads must then be watertight and water will be added until a level of water four feet above the crown of the sewer in the manhole at the upper end of the section is attained. The rate of flow required to keep this required head will be the exfiltration. All tests will be carried on for a length of time and at intervals as ordered by the Engineer.

The infiltration or exfiltration shall not exceed 48-gallons per day, per inch of sewer perimeter per mile of sewer, and no individual leak will be permitted that in the opinion of the Engineer might endanger the pipe-line or the backfill around it. If the leakage exceeds the maximum permitted, the contractor shall immediately make all repairs and replacements that in the opinion of the Engineer are necessary to secure the required water-tightness.

After all repairs are made to the satisfaction of the Engineer, the Contractor shall again make an infiltration or exfiltration test and this procedure will be repeated until a satisfactory test is made, if and when ordered by the Engineer. The cost of any additional testing, as specified by the Engineer, will be at the Contractor's expense and at no additional cost to the Sanitary District.

The Sanitary District shall not be responsible for any damage to the pipe lines or otherwise due to testing.

(49) FLUMING AND BY PASSING

Flumes and by-passes shall be designed with sufficient capacity to carry the maximum storm flow without restricting the flow in the existing sewer. Plans and procedure shall be submitted to the Chief Engineer for approval before proceeding with the work.

(50) SIGNS

Project Construction Signs, if requested, will be furnished, erected and removed under a separate contract, at a location or locations as directed by the Engineer.

The general contractor may attach a tablet of his own to the signs at the place designated by the Engineer, of a size not larger than 9" x 36".

The cost of furnishing and erection of the signs shall not be included in the unit or lump sum price of the contract.

VOID

*USGPO: 1976 — 650-478/1107 Region 5-I